# Chemical Catechism
## for the use of
## Students of Medicine.

Unfinished rough draught.—

Written about 1850;
perhaps sooner.

H. H.

Part I. – Preliminary Considerations.
II. – Heat.
III. – Light.
IV. – Electricity, Galvanism, Magnetism.
V. – Chemical Affinity.
VI. – The Simple Elements.
VII. – Organic Chemistry.

# Part I.

## Preliminary Considerations.–

Question. — What is the widest definition of the term Chemistry?

Answer. — It is the science of molecular reaction; embracing chiefly the study of those reactions which occur between the particles of different kinds of matter.

Q. — What is the principal force which governs chemical phenomena?

A. — Chemical attraction or affinity.

Q. — What do we mean by a force?

A. — Force is the term used to designate that unknown cause of action or change.

Q. — What kind of proof have we of the existence of forces, which are not merely properties of matter?

A. — They cannot be demonstrated; but it is a rational inference from all observation, that every event must have a direct and sufficient cause; and the phenomena ascribed to the forces cannot be accounted for by any known properties of matter.—

Q. — What other forces are much involved

in molecular reactions?

A. — The attraction of gravitation, — of cohesion, — the forces of caloric or heat, — of light, — electricity, — galvanism, magnetism, — and, in living bodies, — the force of life, or organic force.

Q. — What is meant by a molecule?

A. — An ultimate and indivisible particle.

Q. — How do we derive our idea of the definite existence of molecules? —

A. — From reasoning, which mechanical division cannot as yet confirm.

Q. — Why do we believe the atoms or molecules of the same substance to be all exactly alike?

A. — From the facts of definite combination and decomposition, which form the basis of the "atomic theory." —

Q. — What is the distinction between the attraction of cohesion, and chemical attraction?

A. Cohesion exists between homogeneous particles; chemical affinity, between those of different kinds.

Q. Are the particles of bodies in actual contact with each other?

A. No; for all substances are capable of indefinite compression.

Q.- What is that property of matter which causes bodies, after compression is withdrawn, to return to their original bulk and form?

A.- Elasticity.

Q.- In one of what three forms does every kind of matter exist?

A. Solid, liquid, and gaseous. The term fluid is sometimes applied either to a liquid or a gas. A vapor is a gas which is readily condensed.

Q.- In which class of bodies is cohesion most predominant?

A.- In solids. In liquids it is so modified as to allow ~~free~~ intermobility of the particles. In gases, it is entirely overcome, being replaced by elasticity.

Q. – What force is usually the antagonist of Cohesion? –

A. – That of Heat, or Caloric.

Q. By what is the attraction of gravitation modified in different bodies? –

A. By the quantity of matter in each, and by their distance from the centre of the earth, or other attracting mass.

Q. What law expresses the relation of this attraction to distance from the attracting body?

A. That the degree of attraction varies inversely as the squares of the distances.

Q. Does a similar law apply to other forces acting from a fixed centre in right lines?

A. Yes; it is a mathematical result of the relation of the centres of ~~xx~~ spheres to their radii and circumferences; and is applicable to heat, light, and electrical attraction &c.

Q. What is specific gravity?

A. Relative weight; or the weight of a

certain bulk of a substance, compared with the same bulk of a standard body.

Q. What is the most employed standard?

A. Water, in weighing solids & liquids; air, in weighing gases.

Q. How do we obtain the specific gravity of a body heavier than water?

A. By weighing a certain bulk of the body first in the air, - and then immersing the scale containing it in water. It will not weigh so much by a certain quantity. Ascertain this quantity, and divide it into the weight of the body out of water; the result will express the specific gravity desired.

Q. How do you explain this process?

A. The body weighs less in water, on account of the upward pressure of the liquid; but, by an established law, the pressure of a liquid at any point is precisely the same in all directions; hence the upward pressure is equal to the downward pressure or, weight, of the bulk of water displaced, that is, of a bulk of water equal to that of the body weighed.

Q. What simple proportion is thus deduced?

A. As the weight of the given bulk of water is to the weight of the same bulk of the other body,

So is the specific gravity of water, or 1, to the specific gravity of the other body.

Q. Repeat how you obtain the weight of a bulk of water equal to that of the substance weighed.

A. By simply finding the difference between the weight of the body out of water and in water; that is, the resistance or upward pressure of the water against the body.

Q. How would you proceed if the body were lighter than water?

A. Weigh it ~~out~~ in the air & in water as before; as it is buoyed up and will not sink, add sufficient weight to sink it to a level with the other scale. Add the quantity necessary to sink it to the weight of the body in the air, — and substitute this sum for the weight of the body's bulk of water, in the above proportion.

Q. How is the weight of liquids usually compared with that of water?

A. By instruments called hydrometers; so called from their being employed to ascertain the strength of liquids containing a portion of water.

Q. How are they used?

A. They are of different sorts, – but the principle on which they depend is, that any body will sink farther in a light than in a dense liquid. The depth to which a graduated tube, for instance, will sink in water, is noted on its scale, – and the depth to which it sinks in other liquids may then be compared on the same scale.

Q. How was it first proved that the air has weight?

A. By the Torricellian experiment, as it is called.

Q. What ~~was the one~~ subject was this experiment designed to explain?

A. That of suction, by the ordinary pump.

Q. What was the ancient opinion with regard to suction?

A. The simple absurdity, that "Nature abhors a vacuum!"

Q. What was the Torricellian Experiment?

A. A tube, closed at one end, was filled with mercury or water, and then inverted in a vessel of the same liquid. It was found that a column of liquid of a certain height only was sustained, and that above that height existed a vacuum.

Q. If water were used, a column of what height would be sustained?

A. Between 33 and 34 feet.

Q. How high a column of mercury would be sustained?

A. About 30 inches only.

Q. What is the cause, then, of the liquid being supported in the tube?

A. The pressure, or weight, of the atmosphere, acting upon the liquid in the open vessel in which the tube is inverted.

Q. Can this be positively proved?

A. Yes; by opening the closed end of the tube, so as to allow the air to press there also. The liquid will then fall to a level with that in the rest of the vessel.

Q. What is suction, then, philosophically?

A. The removal of pressure from one side of a cavity, so as to allow the pressure, before equal in all directions, to predominate toward ~~in that~~ side, and thus force the contents of the cavity in that direction.

Q. What instrument is founded on the principle of the Torricellian experiment?

A. The barometer, for estimating the varying pressure of the atmosphere. (from βαρυς, weight.)

Q. Why may the barometer also answer to estimate the height of mountains or other elevated points?

A. Because, in ascending through the air, we leave a portion of it below, and thus cause its weight or pressure to be lessened; as the barometer will indicate by the mercury falling in the tube.

Q. Does the air pump differ essentially from the ordinary suction pump for water?

A. No; the principle of construction is the same.

Q. What force takes the place of the general atmospheric pressure, when a closed receiver is exhausted by the air pump?

A. The elasticity of the air contained in the receiver; which causes it immediately to expand, when the space is enlarged, so as to fill it equably.

Q. How could the exhausting be converted into a condensing pump?

A. By simply reversing the valves.

Q. What is the amount of the pressure of the atmosphere at the level of the sea?

A. Between 14 and 15 pounds to the square inch.

Q. How is its constant influence upon the surface of our bodies illustrated?

A. By the effects of ~~its~~ removal, as in cupping, or on ascending to great heights. In the latter case, difficulty in breathing and moving, and with some, hemorrhages are produced.

Q. What is the law ~~of Marriott~~ as to the volume & density of gases?

A. That the volume of a gas is inversely as the pressure; the density is directly in proportion to the pressure.

Q. Does the presence of one gas interfere with the expansion of another through the same space?

A, No. Gases are to each other under ordi-nary circumstances as indifferent as empty space; they are diffused thoroughly, without regard to their specific gravity.

Q, Give an example of this law.

A, If carbonic acid gas, which is heavy, be introduced into the lower part of a tall tube, and hydrogen, the lightest of bodies, into the upper end, it will soon be found that there is as much carbonic acid above as below, and as much hydrogen below as above.

Q. Would the presence of a porous wall or septum between the two gases interfere

with this experiment?

A, No. the gaseous diffusion will take place through plaster of paris, &c, or through any animal or vegetable membrane.

Q, In what animal function is this law important?

A, In respiration: an interchange of gases taking place between the atmosphere and our lungs, through their airvesicles.

Q. Is anything analogous to this diffusion observable in liquids?

A, Yes; analogous, but not identical.

Q, What are some of the facts?

A, That when two liquids of different density are separated by a porous septum, caoutchouc or animal membrane for example, — the two liquids pass through the septum to each other, and intermingle.

Q, What name is given to these phenomena?

A, Endosmose and exosmose; the former being strictly the inward flow or current, the other the flow or current outward; but the name Endosmose is now generally applied to the stronger current.

Q, Is there any law with regard to the Com-

-parative strength of the two currents?

A. Yes. The current is usually stronger from the less dense to the more dense liquid.

Q. Has chemical affinity any influence upon endosmose?

A. Yes, very clearly. If the two liquids are incapable of mixing, as oil and water, or if neither could under other circumstances moisten the septum, endosmose cannot take place.

Q. Is any mechanical power produced by the endosmotic current?

A. Yes; in some cases equal to 4½ atmospheres, or over 60 pounds to the square inch.

Q. Is this thought of consequence in some animal and vegetable functions?

A. Yes.

# Part II.

## Heat.

Q. What other term is synonymous with heat?
A. Caloric.
Q. Do we know anything of the nature or cause of heat?
A. No; it is known only by its effects.
Q. Is temperature, or the effect of heat upon our sensations, the only measure of heat in bodies?
A. No. Temperature is relative only, and therefore quite uncertain. A body may seem hot to a cold hand, when it would give the sensation of coolness to a hot one.
Q. What is the most universal effect of the exposure of bodies to heat?
A. Their expansion.
Q. What class of solids expand most?
A. Metals.
Q. Which of the metals is preeminent in expansion with heat?
A. Lead.
Q. What class of substances expand the

least when heated?

A. Porous organic bodies.

Q. What are pyrometers?

A. Instruments for measuring high heat by its effect in expanding metals.

Q. Do solids ~~expand~~ at the same rate at all temperatures, for the same increase of heat?

A. No; their rate of expansion increases with the temperature.

Q. Do all liquids expand alike with heat?

A. No; alcohol expands more than water, water more than mercury.

Q. Does this expansion bear any relation to the density of the liquids?

A. None.

Q. Do liquids expand at the same rate at all temperatures, for the same increase of heat?

A. No; their rate of expansion increases with the temperature.

Q. What is the most convenient mode of comparing the temperature of bodies or of points in space?

A. By the expansion or contraction of

liquids in transparent tubes.

Q. What are instruments for the purpose called?

A. Thermometers.

Q. Was air ever employed as an expanding medium in thermometers?

A. Yes, by Sanctorio; the instrument resembled a barometer, except that instead of a vacuum, the tube contained air at its upper part.

Q. To what objection was this construction open?

A. The liquid being exposed to the atmosphere, its height in the tube was influenced by the varying atmospheric pressure, so as to render its indications of temperature uncertain.

Q. Can no thermometrical use then be made of air?

A. Yes, in Leslie's Differential thermometer: which consists of a closed tube, ~~having~~ a bulb at each end, & bent in the form of the letter U; each bulb contains air, and the intermediate space is filled with a colored liquid.

Q. How is this instrument used?
A. To indicate the different temperature of ~~the~~ media in which the two bulbs may be placed, by the rising or falling of the liquid in one of them, from the contraction or expansion of the air ~~they~~ it contains.
Q. Why is mercury the best material for the thermometer?
A. Its boiling point is high, and its freezing point low; so that it can be used ~~for~~ at any ordinary degree of heat or cold; and it expands more equably than any other liquid, at ~~all~~ different temperatures.
Q. Does its slightly greater expansion at high heats interfere practically with the correctness of the thermometer?
A. It is corrected by the corresponding expansion of the glass tube containing it.
Q. What is the ordinary process by which thermometers are made?
A. A glass tube of a small and uniform calibre is chosen, and a bulb blown in one end of it, by the aid of heat. While it is still hot, the open end is plunged in mercury, which, as the tube cools, is drawn into it. The mercury is then

boiled to expel the air; and while it thus contains only mercury & its vapor, the end is hermetically sealed by heat.

Q. How is it then graduated?

A. By dipping it first into freezing water, and marking the point to which the mercury sinks; then into boiling water, and marking the point to which it rises; the space is then variously divided.

Q. What scale is most used in this country?

A. That of Fahrenheit, which divides the above space into 180° degrees.

Q. What ~~other~~ scales are somewhat in use in Europe?

A. Those of Reaumur, and ~~of~~ Celsius. The space between the freezing and boiling points of water in the former comprises 80 degrees, — in the latter, the centigrade, 100.

Q. What is zero in these thermometers?

A. In Fahrenheits, it is ~~the degree of~~ cold produced in a mixture of salt and snow; being 32° below the freezing point of water. In the others, zero is at this freezing point.

Q. What is then the boiling point of water, on Fahrenheits scale?

A. 212°.

Q. Do gases vary in their expansion by heat?
A. Very slightly. With few exceptions ~~every~~ gas expands, for each degree of heat, 1/480th of its bulk at 32° Fahrenheit.
Q. Are there any exceptions to the law that bodies expand when heated, and contract when cooled?
A. Yes. The most interesting is that of water; which, on being cooled, begins to expand at 40°, and continues to do so until it is frozen at 32°.
Q. What appears to be the explanation of this?
A. That it results from a mechanical change in ~~of~~ the arrangement of the particles, a part of ~~belonging to~~ the process of chrystallisation or congelation.
Q. What are the practical effects of this fact?
A. That ice is lighter than water, and floats upon it, — so as to allow of the preservation of life in aquatic species during the winter, — which would be otherwise impossible.

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Q. If several different substances are exposed to the same source or supply of heat for a certain time, will they all acquire the same temperature, according to the thermometer?
A. No. Mercury for example, will become, sensibly, ~~twice as~~ much hotter than water in the same

time.

Q. What hypothesis gives the best ~~philosophy~~ expression with regard to this and similar facts?

A. That heat exists in two states — sensible, and latent or insensible; that bodies have the power of absorbing and neutralising different degrees of heat, and again of giving it up under other circumstances.

Q. Are these terms, which imply that heat is a material substance, considered scientifically correct, or are they used only for convenient expression of facts?

A. They are used only for convenience. We are not yet justified in asserting that heat is, nor that it is not, a substance?

Q. If water at 40° and mercury at 100° are mixed together in equal bulks, — will the temperature of the mixture be the mean of those two numbers?

A. No; it will be below the mean; as a certain number of degrees will be absorbed, or become latent, in heating the water.

Q. What other terms express the comparative amount of heat rendered latent by different bodies?

A. Capacity for heat, and Specific heat.

Q. Which has then the greatest capacity for heat, — water or mercury?

A. Water, as it absorbs the most heat for the same sensible or thermometric effect. Water is said also to have a high specific heat, being to that of mercury as 30 to 1.

Q. Does the capacity for heat of a substance vary under any circumstances?

A. Yes; with change of bulk, change of state, as ~~[illegible]~~ in fusion, boiling, or congelation, and ~~with~~ chemical combination.

Q. How does expansion affect the capacity of a ~~substance~~ gas for heat?

A. It increases its capacity for heat.

Q. Does ~~compression~~ condensation decrease it also?

A. Yes.

Q. How then is the sensible heat correspondingly altered?

A. Expansion or rarefaction causes a diminution of temperature, by the absorption of heat, while condensation causes a rise of temperature by latent heat being made sensible.

Q. Is the capacity for heat of a compound

body always the mean between those of its elements?

A. no; a change of temperature is often produced.

Q. What are examples of this?

A. The high heat produced by mingling sulphuric acid and water in certain proportions; and the various saline frigorific mixtures, so called.

Q. Is the fusing point always the same for the same substance?

A. Yes.

Q. What is the melting point of ice?

A. 32° Fahr.

Q. What metal has the lowest fusing point?

A. Mercury, which is liquid until 39° below zero, Fahrenheit.

Q. What metals are next in fusibility?

A. Potassium, sodium, and arsenic.

Q. Of the more common metals, which melt the most readily?

A. Tin and Lead; the former at 442°, the latter at 612°.

Q. Which has the greatest capacity for heat, — ice, or water?

A. Water.

Q. Is a rise or fall of temperature then produced in the melting of ice?
A. Cold is produced.
Q. Is heat also evolved in the freezing of water?
A. Yes; enough to heat an equal bulk of water 140° degrees.
Q. Is 140° degrees Fahr., then, said to be the amount of latent heat of water,
A. Yes,
Q. Does the latent heat of liquids vary?
A. Yes, considerably.
Q. Does the temperature of a solid, while melting, rise above the fusing point?
A. No; all the heat which enters it is absorbed or made latent in the process of fusion; so that it remains constantly at the same temperature till the whole is melted,
Q. Is the same ~~xxxx~~ true of the liquid resulting from the fusion of the solid?
A. Yes; ~~they~~ remain at the same temperature till the whole is melted.
Q. What atmospheric change illustrates the evolution of heat during congelation?
A. The mildness of temperature so often

preceding the fall of snow; being produced by the freezing of moisture in the upper regions of the air.

Q. Why is the air much colder at great elevations?

A. Chiefly because rarefied, under greatly diminished pressure.

Q. May all liquids be converted into vapors?

A. Yes; but by very different degrees of heat.

Q. Do they not however emit a certain amount of vapor at all temperatures?

A. Yes; even ~~many~~ solids, odorous substances for example, and ice itself, give off minute particles in the state of vapor.

Q. What different modes of ~~vapo~~ vaporization occur?

A. Evaporation, which is a comparatively slow process, and ebullition, which is rapid and attended with agitation of surface.

Q. Is the boiling point always the same for the same substance?

A. It is, under the same circumstances only.

Q. What circumstances cause a variation in

the boiling point of liquids?

A. The nature of the vessel, — the extent of surface in comparison with depth, and the amount of atmospheric pressure.

Q. Under ordinary circumstances, what is the boiling point of water?

A. 212° Fahrenheit.

Q. Of Ether?

A. 96°; 80°.

Q. of Alcohol?

A. 173°.

Q. Of mercury.

A. 662°.

Q. At what part of a liquid does ebullition begin?

A. At the bottom, whence the bubbles of vapor first rise.

Q. What pressure must the vapor then over-come before boiling can occur?

A. That of the liquid and that of the atmosphere on its surface.

Q. What effect ~~[illegible]~~ has diminution of pressure on the boiling point of a liquid?

A. That of lowering it. Ether boils in a vacuum at the ordinary temperature of the air.

Q. How does the boiling point of water

vary in ascending to great heights?
A. It lowers one degree for every 548 feet.
Q. Is the elasticity of vapors the same at all temperatures?
A. No; it is greatest at the highest heat.
Q. How can this be ascertained?
A. By introducing them into the Torricellian tube, above the mercury. The tension of the vapor is shown by the depression of the mercury.
Q. When steam is heated under pressure, does its elasticity increase exactly in proportion to the temperature?
A. No; when in contact with water, its elasticity increases much faster than the heat. At 250° it has a pressure of 2 atmospheres, or double its elasticity at 212°.
Q. What is high steam?
A. Steam maintained under pressure while its temperature is raised.
Q. Will a jet of such steam, escaping into the air, feel very hot to the hand?
A. No; because its immediate rarefaction cools it speedily.

Q. Has the density of vapors any relation to the volatility of their respective liquids?

A. No. The vapor of water is the rarest, and that of ether one of the densest of vapors.

Q. Which has the greatest capacity for heat, — steam or water?

A. Steam. Cold is therefore produced by ~~slow~~ evaporation, and over 900° degrees of heat are absorbed in ebullition of water.

Q. This being the latent heat of ordinary steam, then what is said to be ~~the~~ absolute heat? ~~[illegible]~~
~~[illegible]~~?

A. Nearly 1212°; the sum of the latent & sensible heat.

Q. Can water be heated above 212°, at the ordinary atmospheric pressure?

A. No; for all the heat which enters it is made latent in boiling, until the whole is converted into steam.

Q. Is the latent heat of steam high or low compared with that of other gases?

A. It is high.

Q. Is its specific heat, or capacity for heat also comparatively high?

A. Yes.

Spheroidal condition of a heated liquid. —

Q. Does the atmosphere always contain vapor?

A. Yes, in varying amount, from different causes, but tending always to approach a fixed standard.

Q. What determines this standard or law?

A. The temperature.

Q. Does any affinity exist between air and water?

A. Little or none.

Q. How do we ascertain whether the amount of moisture in the air is above or below the standard for the temperature?

A. By what is called the dew point, or by various hygrometers.

Q. How is the dew-point obtained?

A. By cooling gradually a polished vessel in which a thermometer is placed. The temperature at which moisture first begins to condense upon the vessel, is the dew-point. Or, this may be reversed, and the temperature noted at which moisture ceases to be deposited, as the vessel is warmed, after having been colder than the air.

Q. ~~If~~ the air is uncommonly moist,

then, will the dewpoint be high, or low?
A. High; because a very moderate degree of cold will condense the excessive moisture.
Q. What is supposed to be the extent of the atmosphere from the earth's surface?
A. About 45 miles.
Q. Has air ever been condensed into a liquid?
A. No.
Q. By what means have many gases been liquefied?
A. By cold, and pressure; carbonic acid, sulphuretted hydrogen, chlorine &c have been made liquid, and even frozen solid. It is possible therefore that even air may one day be made a liquid.

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Q. What are the chief sources of heat which come under our observation?
A. The sun's rays, - friction and percussion, ~~[illegible]~~ chemical action, with or without vitality, and electricity.
Q. Is the earth dependent altogether upon the sun for its temperature?
A. No; it is supposed to have a ~~[illegible]~~

central heat of its own, so intense that at 25 miles below the surface all rocks are in a state of fusion.

Q. What are the modes by which heat is distributed and interchanged amongst bodies?

A. Conduction, circulation or convection, and radiation.

Q. What class of bodies conduct heat most rapidly?

A. Metals; especially Gold, Silver, & Copper. Glass & clay, silk, wool &c are among the worst conductors.

Q. Do liquids conduct heat at all?

A. Very feebly indeed; careful experiments only prove it in the smallest degree.

Q. How is heat distributed among the particles of liquids and gases?

A. By circulation or convection; that is, the heat is carried by the movement of the heated particles.

Q. Can fluids be heated from above downwards?

A. No; ether may be burned upon the surface of water without affecting the temperature of the latter to the depth of an inch.

Q. Describe the circulation which takes

place when heat is applied at the bottom of a liquid.

A. The heated portion ~~immediately~~ expands, and is thus made lighter than the rest, which ~~[illegible]~~ descends and forces up the hotter particles. These, ~~[illegible] [illegible]~~ on cooling, ~~[illegible] [illegible]~~ become heavier than those ~~[illegible] [illegible]~~ nearest the source of heat; and thus a constant ascending and descending current are kept up.

Q. Are similar atmospheric currents important in producing the various winds?

A. Yes; heat and cold are their chief causes.

Q. Is heat radiated only by bodies which are comparatively hot?

A. No; it is thrown out in all directions by every substance, <u>in proportion</u> to its temperature.

Q. Do all substances radiate heat equally at the same temperature?

A. No. Metals are poor radiators, especially when polished. Organic structures, as cloth, or the leaves of plants, are good radiators.

Q. In what different modes is radiated.

heat disposed of by the bodies which it meets?

A. It is either reflected, transmitted, or absorbed.

Q. Is the term "absorption of heat" philosophically accurate?

A. No; on the undulatory theory, now most approved, neutralisation would be a better phrase.

Q. What substances are the best reflectors of heat?

A. Polished metals. Organic substances are the worst. ~~Reflection~~ is inversely as the radiating power. Lampblack is the best of radiators and the worst of reflectors.

Q. Do any substances transmit heat directly, as glass does light?

A. A few only, to which the term diathermanous or transcalent is applied.

Q. What is the most transcalent of substances known?

A. Rock salt.

Q. Can rays of heat be collected by mirrors or lenses into foci, like those of light?

A. They can; and powerful effects are thus

produced, at considerable distances.

Q. Give an example of these effects.

A. Place a taper in the focus of one parabolic mirror, and a red hot cannon ball in that of another opposite, 60 feet distant. The candle will be lighted. If a thermometer be placed in one focus, and a mass of ice on the other, the mercury will fall to 32°.

Q. What is the explanation of the formation of dew?

A. It is the condensation of atmospheric moisture upon bodies cooled by radiation, after the withdrawal of the sun's rays.

Q. When does the most dew fall, - on clear, or cloudy nights?

A. When the sky is clear; as clouds throw back some of the heat radiated from the earth's surface, and retard its cooling.

Q. Upon what substances will dew form most abundantly?

A. Upon the best radiators; as for instance the leaves and stems of plants.

# Part III.

## Light.

Q. What was Sir Isaac Newton's theory of light?

A. That it consisted of material particles, e-manating in right lines from the Sun and other luminous bodies.

Q. What theory is now pref~~erred by~~ most philosophers?

A. That of Euler; which supposes the phe-nomena of light to be produced by undulations or oscillations in an extremely subtle and universal ether, which pervades all space, and penetrates even ~~throughout~~ the densest solids.

Q. Upon this view, what other physical phen-omena are precisely analogous to those of light?

A. ~~Those of~~ of sound. The vibrations which produce sound are often perceptible to the senses of touch and ~~of~~ sight; the waves of light move with a rapidity so great, and in so ethereal a fluid, as to be appreciated only by the special sense of sight.

Q. Can the undulatory ~~theory~~ of light be positively proved?

A. It is considered not to be so; but one fact approaches nearly to a demonstration.

Q. What is that fact?

A. That when two equal rays of light are brought into direct opposition to each other, they neutralise or destroy each other, producing darkness; just as equal waves, of water for instance, would, on meeting, at once destroy each other's vibration, ~~on meeting~~, and cause rest.

Q. Are the laws of reflection the same for light as for ponderable bodies?

A. Yes; the angle of incidence is equal to the angle of reflection.

Q. Do transparent bodies reflect any light?

A. Yes; under some circumstances glass and water may reflect even more than they transmit.

Q. What is refraction?

A. Literally, the bending of a ray of light from the straight line, in passing from one medium to another, of a different density.

Q. Is refraction the same in different media of the same density?

A. No. Newton ~~observed~~ for instance that combustible bodies were ~~[illegible]~~ remarkable refractors; & hence conjectured the combustibility of the diamond, and

of the elements of water.

Q. In which direction is the ray of light bent in passing from a rare to a dense medium of uniform structure?

A. Towards the perpendicular.

Q. Does our common atmosphere refract light?

A. Yes; as it varies in density, especially from the floating moisture which it contains.

Q. Is refracting power generally in proportion to density?

A. In solids it is: less so in liquids, and the reverse is true in gases.

Q. Is there a constant relation between the angle of incidence and the angle of refraction?

A. Yes, in the same substance.

Q. What is the effect of a prism upon a ray of white light?

A. It decomposes it, into seven colors, forming what is called the Newtonian Spectrum.

Q. What are the seven colors, or rays, of the Spectrum?

A. Red, orange yellow, green, blue, indigo and violet.

Q. Which of these is the most refracted?

A. The violet; the red least.

Q. Are these colors totally distinct, or do they

overlap and blend with each other?
A. They blend gradually into each other.
Q. Is the distance of their dispersion or separation the same, whatever be the material of the prism?
A. No; it differs with the refracting medium.
Q. Can we say correctly that the ray of white light is compounded of the colored rays?
A. Yes; this expresses the observed fact.
Q. How can we synthetically confirm the analysis made by the prism?
A. By an experiment, depending on the fact that impressions on the retina continue for a few moments after being made there. Paint all the colors of the rainbow upon equal radiating divisions of a circular disk, and cause it to revolve rapidly: the impressions of the different colors will succeed each other so quickly as to be mingled, and nothing but white light will be perceived.
Q. Of what three primary colors are the seven hues of the prism all composed?
A. Red, Yellow, and Blue; each of which exists, in different intensity, at all parts of the spectrum.

Q. How are rays of light disposed of by the objects which they meet?

A. They are either reflected, absorbed or neutralised, or transmitted.

Q. By which rays is an object seen?

A. By those reflected, of course.

Q. What proportion of the rays of light does a snow-white object reflect?

A. All.

Q. A black object?

A. None. A red body is so called because it reflects only red rays, &c.

Q. What is the hottest portion of the spectrum?

A. A little beyond the red ray.

Q. Are the rays of light and of heat absolutely identical?

A. No; by using a prism of rock salt, Melloni has separated them entirely.

Q. Has light any important chemical effects?

A. Yes; it seems to be an important agent in the life-chemistry of plants and animals; and various direct changes are produced by it ~~in~~ among inorganic bodies. Of this ~~[illegible]~~ fact the Daguerreotype is the best illustration.

2. What deviations from the ordinary laws of refraction take place when light is passed through certain substances?

A. What are called double refraction, and polarization.

2. What is meant by the former?

A. When a ray of light is transmitted through certain crystals, it is split into two rays; one of which is refracted in the ordinary way, the other takes a new course, dependent on the position of the crystal.

2. What is polarization of light?

A. A change in the properties of ~~a~~ ray by ~~reflexion or~~ reflection or transmission, so that it acts differently from common light when presented at ~~a~~ a ~~certain~~ certain angle to a ~~similar~~ surface; being transmitted when otherwise it would be ~~before it~~ was reflected, ~~or absorbed~~, - or, vice-versa.

2. Of what useful application are these facts capable?

A. They are sometimes of service in testing substances whose other properties may be counterfeited; as polarization is confined to comparatively a few bodies, and is peculiar in each. Diabetic urine for example

Polarized rays are also used to great advantage in microscopy.

# Part IV.

## Electricity.

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Q. What different "kinds of electricity" are spoken of?

A. Frictional or statical electricity, — voltaic or galvanic electricity, and magnetism.

Q. Have the boundaries which separate them from each other been made more, or less distinct by recent observations?

A. Their phenomena have been found to mingle, and to be sometimes convertible; so that they are suspected to be essentially identical.

Q. What is the boldest theory thus suggested?

A. That all the physical forces, — heat, light, electricity, — and even life-force, are merely modifications of movement or vibration in the same ethereal, imponderable, universal ~~ether~~ substance.

Q. Is this at present more than a hypothesis?

A. Nothing more, although defended by some able reasoning.

Q. What is the derivation of the word electricity?

A. It is from ηλεκτρον, amber; the first discovery of it being made by friction with that substance.

Q. What are the simplest of electrical phenomena?
A. If a silk handkerchief and a rod of glass or sealingwax be rubbed together, they will be found to acquire the property of attracting light bodies of any kind; this attraction however being changed to repulsion after a short contact.
Q. Will those light bodies themselves acquire a temporary power of attraction for others?
A. Yes.
Q. If two pith balls are both electrified by contact with a glass rod which has been rubbed, - will they attract each other?
A. No, - they will repel.
Q. If one is electrified by glass, and the other by sealing wax, - will they attract, or repel each other?
A. They will then attract.
Q. How is the law expressed?
A. Similarly electrified bodies repel, dissimilarly electrified attract.
Q. What was Franklin's theory of electricity?
A. That there is but one kind of

electrical fluid, ordinarily in equal quan-
-tity or equilibrium in bodies,—but which
friction or other disturbance causes to become
excessive in some, deficient in others.

Q. What term did he apply to bodies having
an excess of electricity?

A. They were said to be positively electrified;
and those deficient, negatively.

Q. Are all substances capable of either
kind of excitement?

A. No; that developed in glass is always
said to be positive; that in resinous bodies,
always negative.

Q. What is the theory of Dufay?

A. That there are two electrical fluids,
usually in combination and neutralisation;
their union being disturbed by friction &c,
the one accumulates in one locality, and the other
in another; having a strong tendency to reunite
and reproduce an equilibrium.

Q May either theory be made to harmonize
with known facts?

A. Yes; that of Dufay however with the greatest
facility and convenience; while neither is satisfac-
-torily established as positive truth.

Q. What terms, upon Dufay's theory, correspond to those of positive and negative excitement?

A. Vitreous electricity is positive,—and resinous negative.

Q. What are electroscopes and electrometers?

A. Instruments for detecting and measuring electrical excitement, by the power of the attraction which it produces.

Q. How is the gold-leaf electrometer constructed?

A. It consists of a glass cylinder, surmounted by a metallic plate, from which are suspended two pieces of gold-leaf, at a short distance from each other. When an electrified body approaches the plate, the leaves are made to repel each other more or less, by each receiving the same kind of electrical excitement through the plate.

Q. Are all metals conductors of electricity?

A. Yes.

Q. Can electrical excitement, in other words a charge of electricity, be accumulated upon a metallic rod by friction?

Q. No; simply because it is conducted away

& diffused.
Q. What is the relation of the earth to electrified bodies?
A. It is, usually, a great neutral reservoir and conductor of both kinds of electricity.
Q. Is glass a conductor?
A. Glass, sealing wax ~~&c~~ non-conductors; — and therefore capable of accumulating a charge; they are hence called electrics.
Q. What is meant by insulation?
A. The interposition of a nonconducting ~~body~~ substance, as glass or silk for instance, between an ~~excited~~ electrified body and the earth.
Q. — What are the essential parts of the ordinary electrical machine?
A. — A glass cylinder or disk, turned by a handle so as to rub against a rubber of silk (coated sometimes with bisulphide of tin); and an insulated metallic rod or bar, with points at one end, and a knob at the other; the points serving to conduct ~~the~~ electricity from the glass; ~~this~~ this part of the apparatus being called the prime conductor.
Q. When the machine has been charged by friction between the glass and the rubber,

how is a discharge obtained?
A. By connecting the knob of the prime conductor, and the rubber, or a conductor in contact with it, by a conducting material, as a metallic rod.
Q. Will the human body conduct electricity?
A. Yes; with a sensation called a shock.
Q. What is the discharge, expressed according to Dufay's theory?
A. The restoration of an equilibrium, by the reunion of the two separated electricities.
Q. Is contact necessary to a discharge?
A. No; a strong charge will overleap a short distance, giving out light & sound, or what is called a spark.
Q. What is the most magnificent of electric discharges?
A. The lightning flash; which is sometimes several miles long.
Q. ~~What~~ Of what kind is the electricity of the prime conductor of the machine?

A. Positive or vitreous; being obtained directly from the glass.

Q. How is the rubber excited?

A. Negatively or with resinous electricity.

Q. Does connection of the rubber with the earth by a conductor increase or diminish the capacity of the machine?

A. It increases it, by carrying off the positive electricity, repelled by that of the glass, and affording a constant supply of negative electricity to the rubber.

Q. In the thunder storm, what is ordinarily the electricity of the clouds?

A. Positive; and that of the earth's surface negative.

Q. ~~Do~~ Does electrical excitement exist only on the surface, or throughout the substance of bodies?

A. Only to a slight depth below the surface; deepest in ellipsoid bodies, especially at the ends of the longer axis; most equably, in spheres.

Q. What two terms of comparison are used to designate the strength of an electric charge?

A. Quantity, and intensity. By diminishing the bulk or space in which a certain quantity, so to speak, is contained, its intensity is increased.

Q. What effects can be produced by a very powerful charge of frictional electricity?

A. Iron wire may be rendered luminous with heat, — and many gases may be made to combine explosively with each other.

Q. What is electric induction?

A. The excitement of electricity in one body by the proximity of another, without contact or spark.

Q. If an insulated body, for instance, be excited positively, and another, also insulated, be brought near, what kind of electricity will be induced in the latter?

A. Negative; or if it be of some length, negative electricity will be found at the end nearest the other, and positive electricity at the farthest end.

Q. Will induction take place in a vacuum?

A. No; a medium is necessary.

Q. Will it take place through all substances?

A. No; but most nonconductors will answer, — as glass, oil of turpentine &c; such substances being called di-electrics.
Q. Is there a transfer of fluid then from one body to another in induction?
A. No. the name given to the phenomenon is polarization; ~~the~~ resulting from mutual attraction and repulsion between the different electricities in alternate strata or particles of the intervening medium.
Q. What brief definition can you give of the term polarization?
A. Particles are said to be polarized when they acquire a tendency to assume certain relative positions, or poles, towards each other.
Q. Can this tendency be demonstrated in induction?
A. Yes; vaguely, by the facture of a thin glass through which the induction of a heavy charge takes place; more clearly by direct experiment.
Q. In what mode?
A. By using oil of turpentine as the medium and allowing light particles of some sort to

float in it. These will be found to arrange themselves in lines, exten-ding from the first excited body to the one in which excitement is induced.

Q. If you have a glass plate, with a coating of tin-foil on each side, at its centre, one of which coatings is positively excited by the machine; what will be the electrical state of the other?

A. Negative, by induction.

Q. Does the charge then reside in the tin-foil coatings?

A. No; they may be separately removed by insulated holders, and handled freely, without any discharge; when restored to opposite sides of the glass, the excitement can be proved to have remained there, by the ordinary discharge.

Q. Does this seem to shew the electrical force or fluid to be something other than a property of matter?

A. Yes; it gives us the idea of its having a sort of independent existence; using mat-ter as a medium or locality. ~~An argument~~ ~~analogy~~ ~~is thus afforded in moral science, against~~

~~materialism; by showing how possible at least is the independence of mind and matter.~~

Q. How is the Leyden jar constructed?

A. It consists of a glass jar, coated without and within with tin foil, to within an inch or two of the mouth. The inner coating is connected with a rod, with a knob at the end, which emerges, to connect it by conduction with the prime conductor of the machine.

Q. What is the electrical state of the inner coating, when charged?

A. Positive, if connected with the glass, negative, if with the rubber.

Q. How is the outer coating of the jar excited?

A. By induction, it acquires the opposite electricity to that of the inner coating.

Q. Can the strongest charge be obtained with an insulated, or not insulated jar?

A. With one connected with the earth; which then receives all the repelled electricity freely, & affords a supply of that attracted.

Q. How is an electrical battery formed?

A. By connecting several Leyden jars together.

Q. After scrutinising the phenomena of induction, are our ideas of electrical repulsion, so called, modified?

A. Yes; it may be resolved into attraction by surrounding media, also electrified; so that similarly electrified bodies are rather attracted away from each other than repelled.

~~Q. Is it correct to suppose that masses of metal, as lightning rods, "attract the lightning"?~~

~~A. No; they merely conduct it when it reaches them; but it is possible that very large metallic masses, as beds of iron ore, may affect the movement of charged clouds to some extent.~~

~~Q. What is the most efficient arrangement for lightning rods?~~

~~A. Besides surmounting them with one or more platinum points, which remove electricity most quietly and rapidly, to connect them at the bottom with some large mass, of better conducting power than the ordinary earth; for instance, with the water pipes of a city; or a large sheet of~~

~~metal underground~~

## Galvanism - or Voltaic electricity.

Q. What is the most convenient source of voltaic electricity?

A. Chemical action.

Q. What are the necessary circumstances and conditions?

A. Two bodies or surfaces, unequally acted upon by a chemical agent in contact with both; the two surfaces or bodies being also connected by a conductor of electricity, or themselves in contact at one point.

Q. What are the ordinary materials used?

A. Zinc, copper, and dilute sulphuric acid.

Q. What chemical change takes place, when these are arranged as above?

A. The water is decomposed by the affinity of the zinc for its oxygen, forming oxide of zinc; the hydrogen of the water is set free. This action is supposed to begin at the zinc, and pass by alternate decomposition and recomposition of particles, to the copper.

Q. How then do you describe the presence

of the electricity thus developed?

A. A current of voltaic electricity is said to pass from the zinc, which is most acted upon, through the liquid, to the copper, and thence, through the connecting wire out of the liquid, back to the zinc.

Q. What is this simple apparatus called?

A. A voltaic cell or circle.

Q. Will other metals answer instead of zinc and copper?

A. Yes; platinum and iron for instance; the requisite being that one has decidedly more affinity for oxygen than the other. Grove's battery is made with platinum and zinc.

Q. How could a single metal be made to suffice?

A. By using two acids of different chemical power, one on each side of the metal.

Q. May any farther simplification be contrived?

A. One metal and one acid solution will answer, if one side be quite rough and the other polished; as a different degree of action ~~will~~ will be thus obtained.

Q. What is a voltaic or galvanic battery?

A. A series of voltaic cells, connected with

each other — the last copper plate being connected by wire to the first zinc one.

Q. Will all metals conduct voltaic electricity?

A. Yes; but platinum and copper are the best conductors.

Q. Is insulation of the battery needed?

A. No; while the circuit is closed, the current appears to be self-insulating; and when the connection is broken, no electrical excitement is perceived.

Q. Is the form of the battery of much consequence?

A. Not essentially; but advantages may be gained by certain contrivances.

Q. What is one object aimed at by several inventors?

A. To prevent loss of power in the battery with keeping.

Q. What is the cause of its deterioration?

A. The oxide of zinc, dissolved first in the sulphuric acid solution, is afterwards decomposed by the newly set free hydrogen; and metallic zinc is thus precipitated as a coating upon the copper plate.

Q. How may this be prevented?

A. By placing next to the copper plate a solution of sulphate of copper, sufficiently confined by a porous septum, — of plaster of paris for example. This, being decomposed by the hydrogen, deposits only copper, & preserves the apparatus. This the plan of Daniel's Sustaining Battery.

Q. What is another excellent arrangement?

A. To have the plates soldered together and ~~disposed in troughs~~, ~~which~~ so as to fit into a ~~trough~~ ~~each other~~, ~~containing only zinc~~, ~~the other only copper plates~~; in which the acid solution is held. ~~in the battery~~ The plates can thus be turned readily away from ~~the acid~~ when not in use.

Q. What is the best detector and measurer of voltaic electricity?

A. The magnetic needle.

Q. What effect is produced upon it?

A. When held over or under a wire connecting the two ends of a voltaic battery, the needle shews a tendency to arrange itself at right angles to the wire, and also to dip or bend downwards at one end.

Q. Does it ~~always~~ become fixed precisely at right angles with it?

A, No; the amount of motion toward this position varies with the strength or quantity of the current, and is thus a measure of it.

Q, Is any law observed as to the direction in which the poles of the needle move?

A. When the current passes *above* the needle, its north pole being near the copper end of the wire, the north pole is deflected to the east. This is reversed if the current pass *below* the needle.

Q. Which is sometimes called the positive pole of the battery?

A. The copper end; as the electricity commences there to pass through the wire to the zinc, which is said to be the negative end.

Q. What other terms are preferred by some?

A. *Anode* and *Cathode*; from ανω up, and κατω, down.

Q, Do we mean, by the term *current*, that anything can be shown really to pass along the wire?

A. No; but convenience renders the term indispensable. It would seem rather to be a successive action or change of condition

conveyed from particle to particle, anal-
-ogous to the vibrations which cause sound
and light.

2. Has the term polarization been
applied here?

A. Yes; in the sense above expressed.

2. Can any similar effect upon the
magnetic needle be produced by the fric-
-tional electricity of the machine?

A. Yes; and this is one argument for the
essential identity of the two forces or fluids.

2. Can a shock be produced by the
voltaic battery?

A. Yes; chiefly felt at the moment of opening
& closing the circuit.

2. Can intense light and heat be produced
by it?

A. Yes; the most intense heat known;
being capable, it is lately asserted, of fusing
charcoal or the diamond.

2. Can attraction and repulsion between
light bodies be made the consequence
of voltaic electrical excitement?

A. Yes; by a battery of many plates.

2. Does the number of plates affect the

amount of action on the magnetic needle?

A. No. This is augmented by enlarging the plates, which increases the quantity of electricity. A large number of plates, by reacting upon one another, acquire great intensity, as shown by the attraction produced between light bodies, — the shock, spark &c.?

Q. In which then does the voltaic apparatus excel; quantity, or intensity?

A. It is characterized by quantity, while the electricity of the machine is more readily capable of greater intensity, — as displayed for instance in the phenomena of the thunderstorm.

Q. What farther important effect of the voltaic battery requires both great quantity and intensity?

A. The chemical decomposition of liquids, in which the wires are immersed, so that the liquid shall make a part of the circuit by conduction.

Q. What is this mode of decomposition called?

A. Electrolysis; and substances capable of it, electrolytes.

Q. Can only liquids be thus decomposed?

A. Yes; and only such liquids as are conductors of electricity. Solids, as Iodide of Potassium for instance may be decomposed in solution,

Q. Give an example of electrolysis.

A. The decomposition of water, in which the wires of a strong battery are immersed. ~~This decomposition is said to [illegible] to take place from particle to particle; not~~ Oxygen is given off, chiefly at the copper or positive end, and is hence said to be electro-negative; hydrogen, being attracted by the negative pole, is called electro-positive.

Q. Can all bodies be classified according to similar ~~electro~~chemical relations?

A. Yes; and various importance is attached to the fact by different chemists. Oxygen, Sulphur and Chlorine are ~~the most negative~~ negative to all other elements; but sulphur and chlorine are positive to oxygen. Metals are positive compared with other bodies.

Q. Can complex bodies be decomposed by the battery?

A. Yes; many salts, for instance may be separated into acid and base; ~~iodide of potassium is with facility separated into its elements.~~

Q. Are the quantities of the resulting substances always in definite proportion to each other?

A. Always; thus for every 9 parts by weight of water decomposed, 8 parts of oxygen and 1 of hydrogen are obtained.

Q. What hypothesis has been founded on these facts?

A. That of the identity of electricity and chemical affinity. It remains however un-established.

Q. What other remarkable effect can be produced by the voltaic battery?

A. The developement of magnetic properties in iron or steel. The most powerful magnets can be thus produced.

Q. What arrangement affords the greatest convenience for this?

A. The disposition of the wire which connects the poles of a battery, in the form of a coil or helix, through the centre of which the bar is suspended.

Q. Is the magnetism thus imparted permanent?

A. It may become so with steel; but with iron, it ceases when the circuit is broken; depending altogether on the passage of a current of voltaic electricity around the bar at right angles to its axis.

Q. Have wires conveying voltaic currents any effect upon other wires, not connecting the poles of any battery?

A. Yes; they induce currents in them, when in proximity.

Q. If two wires, carrying currents in the same direction are brought near each other, do they attract, or repel each other?

A. They attract; and dissimilar currents repel; the law being the reverse of that which holds with bodies excited with frictional electricity.

Q. What gave origin to the term Galvanism?

A. The observations of Galvani upon electricity; which commenced before those of Volta.

Q. What was the first accidental discovery?

A. Two pieces of different metal coming in

contact with the leg of a frog on ~~the~~ a dinner-table, caused motion in the muscles of the limb.

Q. How is this ~~[illegible]~~ accounted for?

A. By a feeble current of electricity, acting upon a very susceptible organ. The limb of a frog is now found to be a most delicate Galvanoscope.

Q. The result of what homely & familiar experiment is analogous to the above?

A. On placing a piece of copper ~~[illegible]~~ above the tongue, and a ~~silver~~ piece of silver below it, touching each other, a decided impression is made upon the nerves of taste. The saliva is here the chemical agent; the taste disappears when the metals do not touch each other.

Q. Can muscular contraction be produced in the human body by currents of Voltaic or Galvanic electricity?

A. Yes; even for a time after death.

Q. Which is the best conductor of electricity; nerve, or muscle?

A. Muscle.

Q. Do not electrical currents influence the

nervous system, however?

A. Yes, considerably. The Galvanic battery and ~~[illegible]~~ other electrical apparatus are occasionally of service in disease; although as yet very imperfectly applied.

Q. What is the effect of a direct current upon the excitability of a nerve?

A. It ~~acts upon its motor fibres, producing muscular action, and~~ exhausts excitability.

Q. How does an inverse current affect it?

A. An inverse current, i.e. from the termination of a nerve towards its origin ~~[illegible]~~ increases its excitability. ~~It causes pain, & little motion.~~

Q. In what class of diseases then would the latter be most applicable?

A. In those of diminished excitability, as paralysis. The current directly in the course of the nerves, ~~[illegible]~~ might possibly ~~[illegible]~~ be of use in tetanus.

Q. Which affects the system most, — the continued, or the interrupted current?

A. The continued; the effects of an interrupted current are comparatively slight and local.

Q. Are electrical phenomena ever observed

in animal bodies independent of exter-
-ior agency?

A. Yes. Certain animals and fishes have organs specially contrived for the generation or accumulation of electricity; as the Torpedo and the Gymnotus, with which it is a natural weapon.

Q. Is the rationale of this action clearly un-
-derstood?

A. No; it is ascertained however to be always connected with the nervous system, — to be under control of the will of the animal, to be exhausted by use, and renewed during repose.

Q. Have not spontaneous currents been detected in the bodies of man and ~~many~~ other animals?

A. Yes. ~~[illegible]~~ In muscles, from within outward; fr. ends to middle of side; from the liver to the stomach; from the interior mucous membranes to the outer skin.

Q. What cause has ~~been hypothetically~~ assigned to these phenomena?

A. Chemical action. Hence current from capillary terminations toward central portions of the body.

Q. What interesting sources or exciting causes of voltaic electricity remain to be noticed?

A. Heat, and Magnetism.

Q. What name is given to electricity developed by the former?
A. Thermo-electricity.
Q. Under what circumstances ~~is~~ its observed?
A. When ~~then~~ different parts of a conducting mass are unequally heated, a current of electricity is found to pass from the least heated to the more heated part.
Q. Can all the ordinary effects of the battery be thus produced?
A. By a thermo-electric battery, constructed with differently conducting metals, as bismuth and antimony, – ~~all~~ the effects of a voltaic current can be evolved.
Q. What well-known facts are beautifully explained by the theory of thermo-electricity?
A. Those of terrestrial magnetism. ~~will be stated hereafter~~

## Magnetism.

Q. What metals are "capable of becoming magnetic?
A. Iron, nickel and cobalt.

Q. What properties has magnetised iron?
A. It attracts any mass of similar metal; and if suspended so as to move freely, it arranges itself nearly north and south, with a slight dip at one end.
Q. What instrument is thus constructed?
A. The compass-needle.
Q. Does the needle point exactly north in this locality?
A. No; it deviates a little to the west.
Q. Which pole of the needle dips or descends, here?
A. The North pole.
Q. What substance is naturally magnetic?
A. The loadstone; which is a native ore of iron, of different varieties.
Q. How may the properties of the loadstone be conveyed to a bar of iron or steel?
A. By rubbing them together.
Q. Is polarity retained by a magnetic bar when it is bent from the straight form?
A. Yes; the horse-shoe magnet has as much power as any.
Q. Do similar poles of different magnets attract or repel each other?

A. They repel; while the North pole of one attracts the South pole of the other.

Q. Is the bar of iron, called the *keeper* of a magnet, of any use?

A. Yes; its name is given from its serving to *retain* the magnetic power, by induction.

Q. Does the intervention of a non-metallic substance, as paper, prevent magnetic attraction?

A. No.

Q. If a magnet is brought under a paper, on which iron filings are spread, what is observed?

A. The filings arrange themselves in *curves* about the poles of the magnet.

Q. What inference is drawn from this and other facts?

A. That a *current* of magneto-electricity is constantly passing around the poles of a magnet, at right angles to its axis.

Q. How does Ampere explain the mutual attraction of opposite magnetic poles?

A. By the law that similar currents attract, & dissimilar repel.

Q. Can a magnet be made without a loadstone?

A. Yes; by simply suspending a bar of iron or steel in the precise direction of

the compass-needle.
Q. Which is most ~~susceptible~~ capable of permanent magnetism,—iron or steel?
A. Steel.
Q. Repeat what influence the wire of a voltaic battery has upon a magnetic needle held near it.
A. The needle exhibits a tendency to revolve around the wire at right angles to it,—or approaching that position.
Q. Will a needle held for some time across such a wire become magnetic?
A. Yes.
Q. Was it from this fact that the idea of the helix-magnet was deduced?
A. Yes; the science of electro-magnetism has resulted from it.
Q. Has it been applied to the production of mechanic power?
A. Yes, to some extent.
Q. What is the principle of Morse's telegraph?
A. It is an application of electro-magnetism. Impressions are made upon a revolving cylinder, by the alternate making and

unmaking of a helix-magnet, through the closure and interruption of the circuit ~~completed~~ by the wire of the helix. Its special wonder is the length of the wire; which has no necessary limit.

Q. What is the comparative velocity ~~with~~ of the electric current?

A. Almost incalculable; far exceeding that of light.

Q. Can magnets be made to generate currents of electricity?

A. Yes; by ~~th~~ causing a magnet and its keeper to revolve so as alternately to approach and recede from each other, a current is produced, strongest at the moments of contact and of separation, and having all the effects of voltaic electricity.

Q. What is the received explanation of the "north and south" polarity of the magnet;—or, in other words, of the magnetism of the Earth?

A. Thermo-electricity is its supposed cause. As the earth revolves daily on its axis, the eastern ~~portion~~ is always hotter than that farther from the sun's rays. A

current of electricity is thus produced, pas-
-sing from west to east, at right
angles to the earths axis. the earth is thus
made magnetic; or, in other words, – as a
current passes at right angles to the axis
of a magnetic bar or needle, – and as simi-
-lar currents attract each other, the attraction
of the respective poles of the earth for
those of the magnet, is thus explained.

~~Q. Have magnets any perceptible effects
upon the human body?~~

~~A. Very slight; some individuals can perceive
impressions from them, when passed over the
track of superficial nerves.~~

Q. What is Diamagnetism?

A. A property found by Prof. Faraday in
several bodies, of arranging themselves, when
freely suspended, from east to west;
thus being at right angles to the magnetic needle.

Q. Is the whole science of electricity to be
considered far from its completion?

A. Undoubtedly; in its physiological rela-
-tions particularly.

Q. Is there reason to believe electricity
and nerve-force identical?

A. No; the arguments at the present time preponderate against their identity.

# Part V.

## Chemical Affinity.

Q. How is chemical attraction or affinity defined?

A. It is the attraction which exists between the particles of different kinds of matter, ~~and which~~ uniting them into compounds, having mostly other properties than those of their elements.

Q. Is it, like gravitation, always in proportion merely to the quantity of matter?

A. No. It varies with the substances; from a mere adhesive tendency, or capacity of solution, to an intense force, capable of producing great changes. ~~of different~~

Q. What are some of the changes produced by the chemical union of bodies?

A. Alteration of temperature, of volume; of form, colour, taste and smell, and

action on test paper or ^with other chemical reagents.

Q. What is an example of change of temperature produced by chemical affinity?

A. Combustion is nothing more than the chemical union of two bodies, with the evolution of heat and light. Heat is also produced by mingling Sulphuric acid and water; and cold, by the solution of certain salts in water.

Q. Give an instance of change of volume by chemical union.

A. When a certain portion of hydrogen and nitrogen combine, the resulting compound, gaseous ammonia, is condensed to ~~occupies but~~ one half their bulk. ~~of its elements~~ ^in point of experiment, Or, more correctly, when ammonia is decomposed, the resulting hydrogen and nitrogen occupy twice the space they did while combined. If alcohol and water are mingled, the mixture is of less bulk than ~~the~~ ^sum of the two separately.

Q. How is the form of bodies chemically altered?

A. Most strikingly in the change from the gaseous to the liquid ^or solid state, or the reverse; as, by the union of carbonic acid gas

and ammonia, a crystalline solid is produced. The union of a minute portion of hydrogen with arsenic renders it gaseous at ordinary temperatures. The combination of oxygen & hydrogen gases produces water. Minor changes of form are seen in the ~~[illegible]~~ chrystals of certain compounds, being entirely different ~~in some cases~~ from those of their constituents.

<u>Q</u>. Name some instances of change of <u>colour</u> by chemical combination.

A. This is seen, with change of form, in the application of <u>tests</u>. Thus iodine, which is violet-coloured in solution, renders starch blue; a colorless solution of lunar caustic is rendered white by a nearly colorless solution of chlorine; Corrosive sublimate, which is white, renders a colorless solution of iodide of potassium Scarlet, unless in excess; ammonia produces with solution of sulphate of copper a beautiful blue color, &c &c.

<u>Q</u>. What are some interesting facts with regard to the <u>taste</u> of certain compounds?

<u>A</u>, The term acid was first applied only to sour substances; it is now arbitrarily used

to designate a class of compound bodies, some of which are not sour. The caustic taste of alkalies is quite peculiar; and by the union of acids and alkalies, compounds are formed which are called salts from their taste and other properties.

Q. What is the action of acids upon the blue color of certain vegetable infusions?

A. Acids redden vegetable blues. The addition of an alkali to a vegetable blue reddened by an acid, will restore its blue color.

Q. What effect have alkalies on the same blue solutions?

A. They change them to green.

Q. What is another test for alkalies?

A. Alkalies change the yellow of turmeric to brown.

Q. What is the substance ordinarily used in testing for acids?

A. Litmus paper. Litmus is not originally blue, but is made so by an alkali; by neutralising which, acids restore its red color.

Q. What state is most favorable to the action of chemical affinity between bodies; that of solidity, or

fluidity?

A. The fluid state. Cohesion is a powerful opponent of chemical action, by preventing intimate contact of the different particles.

Q. Will bodies act most readily upon each other in masses, or in powder? ~~or solution~~

A. In powder, for the above reason.

Q. Does heat favor or oppose chemical action?

A. Heat favors the occurrence of chemical changes to which a proneness exists; whether that proneness be to a new union or to a decomposition.

Q. What is meant by single elective affinity?

A. Merely the decomposition of a compound of two bodies, A & B for instance, by the presence of a third, C, which has a stronger affinity for A or B than the element united with it has.

Q. What is double elective affinity?

A. The interchange of elements between two compounds mingled together. Thus nitrate of lime and carbonate of ammonia placed together in solution, will be resolved into nitrate of ammonia and carbonate of lime.

Q. Are such elective affinities under the control of any circumstances?

A. They are modified by temperature. Thus at high temperatures nitrate of ammonia would be decomposed by carbonate of lime, forming carbonate of ammonia, on account of the volatility of its ingredients. ~~At high temp~~

Q. What law is there as to the formation of insoluble compounds?

A. Whenever, by any possible arrangement of elements mingled variously in solution, an insoluble compound can be formed, that compound is invariably produced, in preference to others.

Q. If different degrees of insolubility exist, what is the law?

A. The most insoluble is then formed. The precipitates, so important in chemical analysis, derive their existence and value from this law.

Q. Does the proportionate quantity of substances mingled affect their reactions?

A. Yes, frequently. E.G., a few drops of aqua ammoniae will cause a precipitate in a solution of sulphate of copper, which precipitate will be redissolved by a larger quantity of ammonia; &c &c.

Q. What is meant by the nascent state of an element?

A. The fact of its being just set free from combination with one or more other substances; in which state its affinities are more vigorous than after a longer isolation.

Q. Give an example.

A. Instances are very frequent in Organic chemistry. Ordinarily, nitrogen and hydrogen cannot be forced to unite and form ammonia; but when they are both just set free or nascent, in putrefaction, that union readily takes place.

Q. What is catalysis, or the "action by presence?"

A. Effects produced upon bodies by the agency of another present, which is not itself involved in the changes which occur; or which at least does not unite with either of the elements which it disturbs.

Q. To what different classes of actions has the term catalytic ~~~~ been ~~~~ applied?

A. They may be defined by instances. 1. Peroxide of hydrogen is decomposed by metallic gold, the gold uniting neither with the oxygen nor with the hydrogen. 2. While water alone is not decomposed by metallic zinc, the presence of sul-

-phuric acid causes the water to oxidise the zinc rapidly; the resulting oxide of zinc then uniting with the sulphuric acid. 3. A jet of hydrogen being passed upon a piece of spongy platinum in the air, the oxygen of the air combines so rapidly with the hydrogen in the pores of the platinum, as to render the metal luminous and cause the gas to inflame.

Q. Which of these can be clearly explained?

A. The latter, only, with certainty. Porous bodies are found to absorb large quantities of gases, which are thus of course condensed; the particles of different gases, as hydrogen and oxygen, may be supposed to be thus brought into a contact so close as to induce union.

Q. What other name is given to the agency of sulphuric acid in favoring the oxidation of zinc by water?

A. Predisposing affinity. (Resulting affinity)

Q. What is the law of "definite proportions?"

A. That the same body is always composed of exactly the same elements, combined in the same proportions.

Q. Can this be proved either by weight or bulk?

A. Yes.

Q. What is the atomic theory of Dalton?

A. That all bodies are composed of aggregated atoms or indivisible particles; the atoms of the same substance being always precisely of the same size and other properties; but different from those of other substances; & that compound bodies are formed of compound atoms, each containing ~~the~~ atoms of their simple elements chemically united.

Q. Are the atoms of different substance supposed to differ in weight?

A. Yes; and the proportionate atomic weight of different substances can be obtained. The number representing the atomic weight of a body, compared with a standard, is called its equivalent.

Q. How is this number found?

A. By ascertaining the definite proportion by weight in which the substance unites with others.

Q. What is the "law of equivalents?"

A. That the number designating the proportion by weight in which a body combines with one other, denotes that in which it will com-

-bine with any other, capable of uniting with it.

Q. What is the law of multiples?

A. That when one substance combines with another in more than one proportion, these proportions are all even multiples of the first or lowest.

Q. For example?

A. Oxygen combines with nitrogen in 5 proportions. The lowest is 8 parts by weight of oxygen to 14 of nitrogen; the next 16 parts of oxygen; the next 24 part; &c.

Q. Which most frequently varies in these proportions; the electronegative, or positive element?

A. The negative.

Q. What is the nearest approach to an exception to this law of ~~even~~ multiples?

A. The proportion designated by the prefix sesqui. A sesquioxide is a compound of 1 equivalent of an element with 1½ of oxygen; or in stricter harmony both with theory and observation, of two parts of the other element with three of oxygen.

Q. How is the equivalent of a compound body found?

A. By adding together the equivalents of its elements, when known; when not known, by determining the proportion in which it will combine definitely with a body of known equivalent.

Q. What element is usually taken as the standard of atomic weight?

A. Hydrogen; being the lightest of all bodies, its equivalent or combining number may be conveniently stated as 1.

Q. On this scale, what is the equivalent of Oxygen?

A. 8.

Q. Of Nitrogen?

A. about 14.

Q. Of Carbon?

A. about 6.

Q. Chlorine?

A. nearly 36.

Q. Sulphur?

A. 16.

Q. Iodine?

A. 126.

Q. Of Iron?

A. 28.

Q. Of Potassium?

A. 40, or, as recently stated, 39.

Q. How are the combining proportions of gases ~~safely~~ reckoned?

A. By volume; the numbers vary less than those for atomic weights.

Q. How does the combining volume of oxygen compare with that of hydrogen & other gases?

A. It is one half. That is, where 8 parts by weight, or one equivalent, of oxygen, are united with 1 part, or 1 equivalent of hydrogen, by volume, twice as much hydrogen as oxygen will be found united.

Q. What mode of examination is used for such investigations?

A. Explosive combination by the electric spark in a receiver in which the bulk of gases used can be accurately measured. The term eudiometer is sometimes given to such an instrument.

Q. Is the ~~present~~ prevalent chemical nomenclature of modern origin?

A. Yes; for its improved condition the world is indebted chiefly to several chemists of France, amongst whom the name of Lavoisier is most conspicuous.

Q. What is the leading idea of the system?

A. That every term should indicate its ~~own~~ meaning;

that the name of a substance, for example, should describe its composition, and if possible, its leading characters. Arbitrary terms are thus banished, and science much simplified.

Q. How is a compound of two simple elements designated?

A. By the termination ide, appended to the name of the electro-negative element; as the oxide, iodide, chloride of iron &c. In case of combustible elements, however, some chemists prefer the termination uret (from uro to burn) as sulphuret - carburet - hydruret.

Q. If a substance forms several oxides, how are they distinguished?

A. That containing one equivalent of oxygen, & one of the other body, is called the protoxide; that with two of oxygen, binoxide; with three, teroxide; four, quadroxide; five, pentoxide, &c.

Q. If a compound contain one equivalent of oxygen and two of another element, what is it called?

A. A di-oxide of the substance. The same endings apply also to compounds of other elements as chlorides &c &c.

Q. What is a per-oxide? A. That containing the most oxygen of all.

Q. What is the electronegative element of most

ordinary acids?

A. Oxygen. An acid the name of which contains only that of a positive body with a termination, is inferred to contain oxygen; as sulphuric, chloric nitric acids, mean oxysulphuric, oxychloric &c.

Q. If a body form with different proportions of oxygen two acids, how are they to be distinguished?

A. The name of that containing the most oxygen ends in ic, that containing ~~the~~ less, in ous.

Q. If other acid compounds of the same elements exist, how are they named?

A. The prefix hypo is appended to the name of the acid containing less oxygen than another; as hyposulphurous acid contains less oxygen than sulphurous; hyposulphuric, less than sulphuric &c. The prefix per, as perchloric &c, indicates the highest degree of oxidation.

Q. What do oxygen acids combine with?

A. Oxygen bases, or basic oxides; the most active of which are called alkalies; forming, with acids, neutral salts.

Q. What would a compound of sulphuric acid with a base be called?

A. A sulphate of that base.

Q. How would you name a similar compoun

of Sulphurous acid?

A. It would be a Sulphite.

Q. What are chemical symbols?

A. Letters and abbreviations used to designate bodies, so as to abridge the statement of chemi-cal facts.

Q. Give some instances of these.

A. O signifies Oxygen; C, Carbon; Cl, Chlorine; Cr, Chromium; Cu, (Cuprum) Copper; Ca, Calcium; Na (Natron) Sodium; St (Stannum) Tin; Sb (Stibium) Antimony; Hg (Hydrargyrum) Mercury; Ar (Argentum) Silver; Fe (Ferrum) Iron; N, Nitrogen; H, Hydrogen &c. K., Potassium.

Q. How are compounds designated by symbols?

A. If formed of two bodies only, by the union of their symbols; e.g. $HO$ is the oxide of hydrogen or water; $FeO$ the oxide of iron; $NaCl$ the chloride of sodium &c.

Q. How would you write the symbols for the binoxide of hydrogen?

A. $HO_2$.

Q. How those for the dioxide of copper?

A. $Cu_2O$.

Q. How for the Sesquioxide of Aluminium?

A. $Al_2O_3$.

Q. How are more complex compounds ~~then~~ ~~them~~ designated?

A. By introducing the sign + between their simpler or proximate components.

Q. Give an instance.

A. $SO_3 + HO$ is ordinary sulphuric acid.

Q. What is such an expression called?

A. A rational formula.

Q. What would be an empirical formula?

A. A mere aggregation of ultimate element; e.g. $SHO_4$.

Q. How would you designate by symbols the tersulphate of the sesquioxide of iron?

A. $Fe_2O_3 + 3SO_3$; the latter portion indicating the presence of 3 equivalents of sulphuric acid.

Q. What is a formula for alum?

A. $KO.SO_3 + Al_2O_3.3SO_3 + HO$.

Q. Can we always obtain certain rational formulae for complex compounds?

A. No; it is difficult especially in organic substances.

Q. What do we mean in chemistry by a salt?

A. A neutral compound, formed of two bodies having opposite electrical and chemical reactions; and

possessed usually of a certain taste, called saline, and of solubility.

Q. Did similarity of physical properties to those of sea salt originate the term?

A. Yes; and it was ~~then~~ afterwards given to other bodies similar in chemical composition either to sea-salt or to other bodies their called salts.

Q. Are all salts soluble?

A. No; Sulphate of baryta is called a salt, from its being composed of an acid and an alkaline earth, ~~and~~ from being itself neutral to test-paper, ~~although~~ it is very insoluble. There are a number of other insoluble salts.

Q. What two classes of salts are there, according to their composition?

A Those similar in composition to sea salt, and hence called haloid (from ἅλς, salt), and those composed each of an acid united with a base.

Q. What is the composition of sea-salt?

A. It is the chloride of sodium.

Q. What is meant, chemically, by an acid?

A. A compound body, having some at least of the following properties: power of uniting with

other compounds containing one of the same ele-
-ments, and neutralising their reactions; the
property of reddening litmus paper; and sourness
of taste. The latter property is the least es-
-sential in a chemical view.

Q. What is the principal acidifying element?

A. Oxygen; named from οξυς, acid, and
γενναω to generate.

Q. Does oxygen also form basic compounds?

A. Yes; some oxides of the same element
may be acids, while others are bases.

Q. What other element forms acid and basic compounds?

A. Sulphur; the sulphurets of hydrogen and
of carbon are often called sulphydric and
sulphocarbonic acids.

Q. Will an oxygen acid unite with a
sulphur base?

A. No; acid oxides unite only with ox-
-ygen bases, and sulphur acids only with
basic sulphurets.

Q. What was Dr Hare's definition of acids
and bases?

A. "When, of the two compounds, each containing an element
common to both, into which a ~~salt~~ is divided
by electrolysis, the one is electronegative, and the

other positive the former is called an acid, and the latter a base".

Q. What name is sometimes given to the element which is common to both acid & base?

A. That of an amphigen or bas-acigen element,

Q. What elements form simple binary salts, like chloride of sodium, called haloid salts?

A. Besides chlorine, the halogen elements are iodine, bromine, and fluorine.

Q. What is a radical?

A. An element, or integral portion of any compound.

Q. Does this term indicate an undecomposable or ultimate element?

A. Yes, if used without qualification.

Q. Will an acid or a base ever unite with a simple element?

A. No. Simples unite with simples, compounds with compounds.

Q. Are there no exceptions to this rule?

A. Only in the case of what are called pseudo-elements, or compound radicals.

Q. What is a compound radical?

A. A substance which, although compound,

combines ~~it~~ with simple bodies, and acts in its chemical relations exactly as if it were an ultimate element.

Q. What is an example of this class?

A. Cyanogen, which is the bicarburet of nitrogen.

Q. Are the compound radicals mostly inorganic, or organic?

A. Organic.

Q. Mention the name of a compound of cyanogen.

A. The cyanide of sodium; precisely analogous to the chloride or iodide of sodium; cyanogen being then a compound halogen element.

Q. What would be an amphigen salt containing sodium?

A. The sulphate of soda.

Q. What is its formula?

A. $NaO + SO_3$; or, empirically, $NaSO_4$.

Q. Are all chemists satisfied with the first of ~~these~~ as the true mode of grouping?

A. No. Liebig and others propose another; viz. $Na + SO_4$; calling $SO_4$, or sulpheon, a compound radical like cyanogen.

Q. What would the sulphate of soda be called,

on this theory?
A. The Sulphionide of Sodium.
Q. What advantage has this hypothesis?
A. That of simplifying the arrangement of salts, by dividing them all merely into salts of simple radicals, as chlorides &c, and salts of compound radicals, as those of cyanogen, sulphoxygen &c.
Q. Are there any important facts to confirm this saltradical theory as being the true one?
A. Yes; for instance the constant and close analogy between all the so-called haloid and amphigen salts of the same metal, in chemical, and even physical properties; making it reasonable to suppose them members of the same class or family of compounds.
Q. What is the chief difficulty in the way of the theory?
A. The fact that the supposed compound radicals of amphigen salts cannot be isolated.
Q. Have not some organic compound radicals been isolated?

A. Yes, several, of which cyanogen is one.

Q. What influence, however, must this difficulty have upon chemical language?

A. It must compel us, for a time at least, to adhere generally to the old phraseology, which supposes an amphigen salt to be a true binary compound of an acid and a base, united as such; for instance, $NaO + SO_3$.

# Part VI.

## The simple elements.

Q. How many elements remain as yet undecomposed?

A. About 63.

Q. What is the most natural division of them?

A. Into metallic and non-metallic.

Q. How are the non-metallic elements classifiable?

A. Into halogen, basacigen, and neutral elements.

Q. Repeat the names of the halogen elements.

A. They are Chlorine, Bromine, Iodine & Fluorine.
Q. What elements are called amphigen, or bas-acigen?
A. Oxygen, Sulphur, Selenium and Tellurium.
Q. What are the remaining non-metallic elements?
A. Carbon, Boron, Phosphorus, Hydrogen, Nitrogen, Silicon.
Q. What element is the most abundant in inorganic matter?
A. Oxygen.
Q. In organic substances, what is the most abundant?
A. Carbon.

## Oxygen.

Q. What substances contain oxygen in the greatest amount?
A. Atmospheric air, and water. It also exists in the soil and rocks, in the form of oxides and oxygen salts, — and in organic bodies.
Q. Is it ever found isolated in nature?
A. No; its affinities are so active and numerous as always to find material for

combination.

Q. What proportion by volume does oxygen form of the air?

A. One fifth, to four fifths nitrogen.

Q. ~~What~~ What proportion by weight does it exist in water?

A. Eight ninths, to one ninth hydrogen.

Q. When artificially isolated, what form does oxygen assume?

A. That of a gas.

Q. Has it ever been liquefied?

A. No.

Q. How may pure oxygen be most readily obtained?

A By heating the chlorate of potassa so as to decompose it.

Q. What apparatus is employed for this purpose?

A. A retort, and the pneumatic trough.

Q. Describe the latter.

A. It is a simple trough containing either water or mercury, in which a shelf projects for a certain distance just below the surface of the liquid. A bell-glass or receiver is inverted upon this shelf, after being

filled entirely with liquid from the trough. The pressure of the atmosphere retains the liquid in the inverted receiver. If then the beak of a retort containing a mixture generating gas, be introduced under the edge of the re-ceiver, the gas rises to the top of it, in bubbles, and displaces the liquid from above. A receiver of any size may be thus filled with gas, without any admixture of air.

Q. When is the mercurial trough preferred?

A. In the preparation of gases which are freely absorbed by water.

Q. What ~~metallic~~ oxides yield oxygen readily when heated?

A. Those of manganese, lead & mercury.

Q. How many equivalents of oxygen does one of chlorate of potassa contain?

A. Six.

Q. How are these arranged, according to the ordinary statement?

A. 5 atoms of oxygen in one of chloric acid,

$ClO_5$, and one atom in Potassa, KO.

Q. How many of these may be driven off by heat?

A. All.

Q. What is the residue?

A. Chloride of ~~Potassium~~.

Q. What is Potassa, then, chemically?

A. The oxide of potassium.

Q. What is the equivalent of Chlorate of Potassa?

A. Being formed of one equivalent of chlorine (36), with one of potassium (40), and six of oxygen (48), it is their sum, or 124.

Q. From every 124 grains of the chlorate, then, how many grains of oxygen can we obtain?

A. 48 grains.

Q. What are the ~~[illegible]~~ properties of oxygen gas?

A. It is colorless, tasteless, inodorous, a little heavier than air, is the chief supporter of combustion, and the only supporter of animal respiration.

Q. Is pure oxygen respirable?

A. Only for a short period; as its effects when undiluted are excessively stimulant.

Q. What is combustion?

A. Active chemical combination, with the evolution of ~~sensible~~ heat, and usually light.

Q. Is the term supporter of combustion properly limited to a few substances?

A. Strictly speaking, no; as the mutual affinity of bodies which thus unite is the cause of their union. The difference between combustibles and supporters of combustion is only apparent or nominal.

Q. Is the amount of heat produced by slow combustion as great for the same material as when the process is rapid?

A. Yes — the aggregate is the same.

Q. What is flame?

A. Gas made luminous by intense heat.

Q. What gives the greatest brilliancy to flame?

A. The presence of unconsumed solid particles.

Q. Is the heat of flame greater than

that of incandescent metals?
A. Yes; much greater.
Q. How does the burning of substances in pure oxygen differ from combustion in the air?
A. It is more rapid, vivid, and brilliant.
Q. Name some illustrative experiments.
A. The sparkling combustion of a coil of iron wire in a receiver of oxygen: the very brilliant combustion of phosphorus, and of sulphur, the latter with a beautiful purple light.
Q. What is the result of the first experiment?
A. The formation of oxide of iron.
Q. Does the iron weigh more, or less after burning, than before?
A. More, by the weight of the oxygen added to it.
Q. What is the result of the above experiment with phosphorus?
A. Phosphoric acid is formed ($PO_5$) & if water is present, will be absorbed & dissolved.
Q. What takes place when sulphur is burned?
A. Sulphurous acid ($SO_2$) is produced.

Q. In the case of phosphorus, how would you detect the acid nature of the product?
A. By the solution reddening litmus paper.
Q. Would this also be true of the sulphurous acid?
A. Yes, at first; but afterwards the litmus would be bleached. This effect is peculiar to sulphurous acid.
Q. If charcoal is burned in air or oxygen over limewater, what change takes place?
A. The limewater becomes turbid, from the presence of carbonic acid, the result of the combustion of carbon.
Q. What is the lightest of all known substances?
A. Hydrogen gas; which is 16 times lighter than oxygen. 100 cubic inches of it weigh between 2 and 3 grains.
Q. Has it ever been liquefied?
A. No.
Q. What are its properties?

A. It is, when pure, colorless and without odor or taste; will burn in the air or in oxygen gas, but will not support the combustion of inflammable bodies, nor the respiration of animals.

Q. If breathed for a short time, what curious effect is produced?

A. A singular modification of the voice.

Q. What is the product of the combustion of hydrogen with air or oxygen?

A. Water.

Q. Does hydrogen exist in nature otherwise than in water?

A. Yes, in organic substances chiefly.

Q. Does much light attend the burning of pure hydrogen?

A. No; very little.

Q. Does its combustion produce much heat?

A. Yes, a very high degree.

Q. What apparatus has been contrived for this effect?

A. The compound oxyhydrogen blowpipe, perfected by Professor Hare.

Q. How are the gases introduced to each other in this instrument?

A. Each passes in a jet through a fine tube, from a separate reservoir; when ignited, the common jet produced by their meeting burns with intense heat.

Q. What are some of its remarkable effects?

A. The melting of platinum, which resists the hottest furnace; and the incandescence of lime, - giving the brilliancy of the Drummond Light.

Q. Why must the gases be kept in separate reservoirs?

A. Because, if mingled, the combustion would be so rapid & violent as to cause a destructive explosion.

Q. Will not an explosive combustion take place through the tubes ~~through~~ which the gases pass?

A. No; if they are of sufficiently small diameter; fine tubes prevent the passage of flame.

Q. How do they prevent its passage?

A. By the conducting power of the metal of which they are formed; the gas, in passing, is by it cooled below the temperature of flame.

Q. What admirable invention was based upon this principle?

A. That of the Safety-lamp of Sir Humphrey Davy.

Q. When a jet of hydrogen gas is burned in a glass tube, what is noticed?

A. A series of musical sounds; produced by very minute and rapid explosions. Water is deposited on the interior of the tube.

Q. In what proportion do oxygen and hydrogen combine explosively when heated?

A. Two parts by volume of hydrogen always unite with one of oxygen.

Q. By weight, what is the proportion?

A. one equivalent, or 8 parts of oxygen unite with one equivalent or 1 part by weight of hydrogen, to form ~~one~~ equivalent or 9 parts of water.

Q. How may a mixture of these gases be exploded without fire?

A. By the electric Spark.

Q. How may we ascertain the bulk of oxygen or hydrogen which exists in any gaseous mixture?

A. By the eudiometer. It is only necessary to introduce a known bulk of ~~the~~ one of these two gases, and explode by electricity, to ascertain, by the change of volume produced, the quantity of the other present. This follows from the law above mentioned, that one volume of oxygen always unites with

two volumes of hydrogen to form water.

Q. If, then, you introduce, into a mixture of gases containing one volume of oxygen, three volumes of hydrogen; how much of the mixture will dis-appear on explosion?

A. The whole bulk will be reduced (if over the pneumatic trough) by three volumes; including the two introduced.

Q. If you had introduced four volumes of hydro-gen, and found six volumes to disappear in the formation of water, — how much oxygen gas must have been present?

A. Two volumes.

Q. How may the combustion of hydrogen be produced without heat or electricity?

A. By passing a jet of the gas upon spongy platinum.

Q. How is this effect of the platinum designated?

A. It is called catalysis; and is accounted for by the hydrogen and the oxygen of the air being absorbed into the pores of the metal, and thus brought into close contact in the molecular state.

Q. How is hydrogen prepared for experimental purposes?

A. By the decomposition of water; either by passing

steam over iron filings heated red hot in a gun-barrel, —or, more readily, by the action of dilute sulphuric acid upon zinc or iron filings.

Q. Will water alone act upon zinc?

A. No; neither will sulphuric acid alone; the acid seems to predispose or induce the decomposition of water by the metal.

Q. What compound results from this action?

A. Sulphate of the oxide of zinc.

Q. What is ~~Hare's~~ self-regulating reservoir? ~~Fig~~ ?

A. ~~A~~ A saucer containing zinc is suspended in a ~~bell glass~~, which has a stopcock at ~~the~~ top; & the bell glass is immersed in a solution of sulphuric acid. If the stopcock is opened, the solution acts upon the metal, and developes a supply of hydrogen gas; when the cock is turned so as to prevent its escape, the gas forces down the solution in the bell glass below the saucer, and no more hydrogen is formed.

Q. Do oxygen and hydrogen form any other compound besides water?

A. There is a deutoxide or peroxide of hydrogen, called sometimes oxygenated water.

Q. How is this obtained?

A. By adding a dilute acid to the deutoxide of Barium. This oxide does not unite with acids, but the protoxide of Barium will. $BaO_2$ then becomes $BaO$, — and the other atom of oxygen combines with the water, forming $HO_2$.

Q. Is this peroxide similar to water in properties?

A. It is heavier, has a syrupy consistence and caustic taste; explodes at 212°, — and is decomposed by metallic oxides and some pure metals, without the latter combining with its oxygen; the action being catalytic or by presence.

Q. Is water of importance in its chemical relations?

A. Yes, — in many ways.

Q. Is it ever pure in nature?

A. It always contains other substances. Snow and rain water are the purest, but contain Carbonic acid, ammonia, and organic matters. Spring waters contain various salts &c, — and river water holds in addition considerable quantities of organic matter.

Q. Does water absorb atmospheric air?

A. It does, — but dissolves its oxygen gas in greater amount than nitrogen. The respiration of fishes is thus accommodated.

Q. Does water form definite compounds with any other

bodies?

A. It combines with bases as an acid, — forming hy-drates, — of which slaked lime is an example. It also combines with acids as a base. Oil of vitriol and aqua fortis are, respectively, the sulphate & the nitrate of water.

Q. Does it not also unite with neutral salts?

A. Yes, — in two modes. 1. As water of crystallisa-tion — important to the mechanical form. 2. As a constituent portion of the saline compound. Many salts are decomposed if entirely deprived of water.

Q. How many equivalents of water has one of Glauber's Salt?

A. 10 equivalents. All of these but one however may be driven off by heat; one is constitutional or essen-tial to the salt. It may be replaced, however, by another salt.

Q. How many parts of water has Epsom Salt?

A. 7 parts; only one being constitutional water.

Q. Is water of consequence in organic bodies?

A. Yes; it is more universal and indispensable than any other body in both plants and animals.

Q. Besides what has been mentioned, what property of water renders it of constant value to the chemist?

A. Its very extensive powers as a solvent of other substances.

Q. What gaseous element resembles oxygen in its chemical relations?

A. Chlorine.

Q. Where does this exist in greatest amount?

A. In sea-water, — in the form of <u>chloride of sodium</u> or common salt. All salt-deposits of course contain it.

Q. How may the chloride of sodium be readily decomposed?

A. By a solution of sulphuric acid.

Q. If oil of vitriol and common salt be mingled in a retort, what reactions occur?

A. The water which is combined with the sulphuric acid is decomposed; its oxygen uniting with the sodium of the salt, and its hydrogen uniting with the chlorine; the <u>oxide of sodium</u> ~~is~~ formed then combines with the sulphuric acid.

Q. What two compounds are thus produced?

A. <u>Sulphate of soda</u>, — and <u>chlorohydric acid</u>.

Q. What are the properties of the latter?

A. It is a gas, of pungent odor & acid taste colorless ~~when~~ pure, and when dry neutral in chemical reaction ~~properties~~, but having an <u>intense</u> affinity for water, a minute portion of which confers upon it the ordinary chemical

properties of acids.

Q. Can it be prepared over the ordinary pneu-matic trough?

A. Not with water; as its rapid absorption defeats the experiment. It should be collected over mercury.

Q. What is its solution called?

A. Muriatic acid.

Q. By what apparatus is this prepared?

A. By Woulffe's bottles; which allow it to pass into a series of double-mouthed bottles containing water, so that it is gradually and safely dissolved. The solution in the first bottle is the most impure.

Q. May hydrochloric acid gas be formed by the direct union of its elements?

A. Yes. by the electric spark, by a red hot body, by exposure to the sun's rays, or by spongy platinum.

Q. What is its atomic constitution?

A. It consists of one equivalent or 36 parts by weight of chlorine, and one equivalent or one part by weight of hydrogen.

Q. Has commercial muriatic acid any color?

A. Yes, it is yellowish, from impurities.

Q. When this acid is exposed to the air, what occurs?

A. White fumes are given off, from combination of its vapor with the moisture of the air.

Q. How is pure Chlorine obtained?

A. In either of two modes. The first, — by mixing binoxide of manganese with chlorohydric acid. The other, — by mixing binoxide of manganese, common salt, and dilute sulphuric acid, together.

Q. Express, by symbols, the rationale of the first process.

A. $MnO_2 + 2HCl$ become $MnCl + 2HO + Cl$.

Q. What formula would explain the second?

A. $MnO_2 + NaCl + 2SO_3 = MnO,SO_3 + NaO,SO_3 + Cl$.

Q. Express this statement in words.

Q. One equivalent of binoxide of manganese gives ~~an~~ equivalent of oxygen to the sodium of the ~~equivalent of~~ chloride of sodium, — which thus sets free its chlorine, & is converted into soda; this soda, then, — and the prot-oxide of manganese, each unite with an equivalent of sulphuric acid. The free chlorine passes over through the retort, & may be collected, over the pneumatic trough.

Q. What proportion of sea-salt consists of chlorine?

A. Three fifths.

Q. Has salt any importance in the vegetable and animal kingdoms?

A. Yes; it is almost indispensable throughout both, - in various amount.

Q. What are some of the properties of Chlorine?

A. It is a yellowish-green gas (hence named) twice and a half as heavy as air, irrespirable, irritating the glottis even when dilute. It is absorbed to considerable amount by water.

Q. Will it support combustion?

A. A lighted taper will burn for a time in chlorine, with much smoke, from the imperfect combustion of its carbon. Phosphorus, arsenic, antimony, and zinc, in a finely divided state, take fire spontaneously in it.

Q. What is its most important chemical proclivity?

A. Its strong affinity for hydrogen; which it will by degrees separate from water, or from any other of its compounds.

Q. What useful applications can be made of this affinity of chlorine for hydrogen?

A. By taking the latter element from coloring matters, chlorine bleaches; and by destroying

odorous compounds, (sulphydric acid e.g.) it is useful in fumigation.

Q. Is it thought capable of destroying powerful contagious and infections in this mode?

A. This remains doubtful; although its deodorizing powers prove it to be useful in correcting a foul atmosphere.

Q.- What is the best test for chlorine?

A.- Silver, in solution; as in the form of nitrate of silver.

Q. What results from the action of chlorine on a solution of nitrate of silver?

A.- A white precipitate of chloride of silver, which is soluble in ammonia, and blackens after exposure to light. (This latter change is said to require the presence of a minute portion of organic matter.)

Q. Are there no other chlorides which are white & insoluble?

A. Yes; those of lead and mercury. But neither of these blackens in the light, nor is dissolved by am-monia.

Q. What other compounds of silver resemble the chloride?

A. The bromide, and cyanide. The above-named peculiarities, however, still distinguish it; while

the cyanide also yields prussic acid with muriatic acid.

Q. What important chemical property of chlorine remains to be mentioned?

A. Its power to dissolve gold.

Q. How is this usually developed?

A. In aqua regia, or nitro-muriatic acid; which is made of 2 parts muriatic to one of nitric acid, — which mutually decompose each other, giving free chlorine in solution.

Q. What elements are closely analogous to Chlorine?

A. Bromine, Iodine, and Fluorine.

Q. Under what head are these all classed together with regard to their metallic compounds?

A. As the four "halogen" elements. The chlorides, bromides, iodides and fluorides of the alkaline metals are all soluble, and analogous to sea salt. They are also prone to form double salts.

Q. What is the respective condition of the above-named halogen bodies, at ordinary temperatures?

A. Fluorine is a gas, — Bromine a liquid, — and Iodine a solid.

Q. Where are Bromine & Iodine found in nature?

A. In sea-water, and some inland springs. The

water of the Dead Sea contains them.

Q. What salt of Bromine is most abundant?

A. The Bromide of Magnesium; a haloid salt, precisely analogous to the Chloride of Sodium.

Q. How may pure Bromine be obtained.

A. From the Bromide of Magnesium, by the addition of sulphuric acid & binoxide of manganese. The residuum is sulphate of protox. of manganese.

Q. What is the color of Bromine?

A. Brownish-red by reflected, and hyacinth by transmitted light.

Q. Is it heavy?

A. Very; three times as heavy as water.

Q. What other properties has it?

A. It is very volatile, - boils at 116°, is pungent and of rather disagreeable odor, - discolors the skin, and disorganizes organic bodies by its affinity for hydrogen. Phosphorus burns explosively in it.

Q. Will it freeze?

A. Yes, at 10° Fahrenheit.

Q. How do its affinities compare with those of chlorine?

A. They are feebler; chlorine will decompose its compounds.

Q. Is its vapor heavy?

A. 5 times as heavy as air.

Q. By what properties is Bromine most easily distinguished?
A. By its weight, and the peculiar color & odor of its vapor.
Q. What chemical action gives somewhat of a test for it?
A. The addition of a salt of silver yields the bromide of silver, a white precipitate, known from the chloride by being very little changed in the light, and scarcely soluble in ammonia.
Q. In what combination is iodine most frequently found?
A. In the form of iodide of sodium, or of potassium; as in the ashes of marine plants (barilla & kemp).
Q. How is free iodine procured?
A. By adding sulphuric acid and binoxide of manganese to the iodide of sodium or potassium; precisely as in the ~~prepar~~ preparation of chlorine from chloride of sodium.
Q. What is the appearance of iodine at ordinary temperatures?
A. It is solid, in the form of small octohedral plates, looking like micaceous iron ore.
Q. Does it affect the color of the skin when touched?
A. Decidedly; giving it a deep brownish yellow stain.

Q. Is iodine soluble in water?

A. Yes, to some extent; more so in alcohol, and in ether.

Q. What solution of it is used for medical purposes?

A. That made with iodide of potassium; whose solution dissolves iodine very readily. An officinal preparation of this kind (Liq. Iodini Comp.) is called Lugol's solution.

Q. What are the melting & boiling points of iodine?

A. It fuses at 226°, - vaporizes at 376.

Q. What is the color of its vapor?

A. A peculiar purple violet; a beautiful color.

Q. What is its weight.

A. It is the heaviest of all vapors; being 8 times as heavy as atmospheric air.

Q. What acids will decompose all haloid salts of iodine with the aid of heat?

A. Strong sulphuric or phosphoric acid; giving off iodine, with the production of iodic acid also; especially if bioxide of manganese be added.

Q. What colored precipitate does free iodine give with nitrate of silver solution?

A. The yellow iodide of silver; which is

very soluble in ammonia.

Q. What is a more delicate test for free iodine?

A. Starch; which gives a blue color with a very minute portion of it.

Q. To apply this test to a salt of iodine, as the iodide of potassium for instance, what is added?

A. An acid, — or chlorine, — to decompose the salt, and set free the iodine. The acid acts of course by predisposing the combination of the oxygen of water present with the metal of the salt.

Q. What, however, is the most delicate test for iodine?

A. The Bichloride of Palladium; a rare compound, — which gives a brown precipitate of the iodide of palladium.

Q. What is the equivalent of iodine?

A. 126.

Q. Do Iodine & bromine combine with oxygen?

A. They do, — with feeble affinity however. Iodous, Iodic and Per-Iodic acids exist, — as well as Bromic and Per-Bromic — analogous to the oxygen acids of chlorine.

Q. Are there also corresponding hydrogen compounds

of iodine and bromine?

A. Yes; iodohydric & bromohydric acids.

Q. Do the same elements also unite with nitrogen?

A. They do, — forming the explosive ter-iodide and ter-bromide of nitrogen, — analogous to ~~its~~ quadro-chloride, which is very explosive.

Q. Returning then to the combinations of chlorine, as the most important halogen element, — what are its oxygen compounds?

A. They are four, — all gaseous when free, and explosive from the very feeble affinity which unites their elements.

Q. What are they?

A. Hypochlorous, ~~Hypochloric~~, Chloric and Perchloric acids.

Q. Designate their composition respectively by symbols.

A. $ClO$, $ClO_4$, $ClO_5$, $ClO_7$.

Q. Which of these forms the most stable compounds?

A. ~~A~~ Perchloric acid, — $ClO_7$.

Q. Is this according to the general rule?

A. No; it is a decided exception; as usually the permanence of a compound body is

in proportion to its simplicity and paucity of component elementary atoms or equivalents.

Q. What is the color of chlorous & hypochloric acid gases?

A. Yellowish green.

Q. Will either of them bleach?

A. Hypochlorous acid will.

Q. In composition and chemical functions, what acid does chloric acid most resemble?

A. Nitric acid.

Q. In what important respect particularly?

A. That, containing the same number of equivalents of oxygen, - these acids are alike ready to part with them, thus being useful as oxidizing agents.

Q. By what property, resulting from this, are the salts of nitric and chloric acids distinguished?

A. All nitrates and chlorates deflagrate when thrown upon burning charcoal; that is, they increase the vividness & activity of combustion so as to make it explosive.

Q. May chloric acid be isolated?

A. No; it is decomposed if separated from combination with all basic substances (of which, it is to be recollected

that water is one).
Q. How does Fluorine exist in nature?
A. Chiefly in what is called fluor spar; which is the fluoride of calcium.
Q. Has it been isolated and examined?
A. Yes, with difficulty.
Q. What constitutes this difficulty?
A. The fact that it acts chemically upon glass.
Q. What chemical effect has it upon that substance?
A. It combines with the silicon which it contains, — forming the fluoride of silicon, or fluo-silicic acid.
Q. In what kind of vessel has it been occasionally prepared for experiment?
A. In a leaden retort.
Q. Is it gaseous?
A. Yes, at ordinary temperatures.
Q. What other acid compounds does Fluorine form?
A. Fluohydric, — which also will etch or corrode glass, — Fluo-boric, or the Fluoride of Boron, and a compound of the fluoride of hydrogen with the fluoride of Silicon, — called Fluo-hydro-silicic acid. There is also a corresponding fluo-hydro-boric acid.

Q. What gas, besides oxygen, exists in atmos-
-pheric air?
A. Nitrogen.
Q. In what series of complex substances
is nitrogen a very important element?
A. In organic bodies; especially in those con-
-nected with animal life.
Q. Why was nitrogen once called azote?
A. Because it is, when pure, incapable of sup-
-porting life by respiration.
Q. Has it any striking or active properties
when isolated?
A. None at all; it is distinguished by the absence
of any physical activity.
Q. Is the same assertion true of its compounds?
A. By no means. The compounds of nitrogen
are generally characterized by great mobility and
activity, chemical and physical; as for instance
nitric acid, – prussic acid, ammonia, &c.
Q. In what proportion does nitrogen exist in the
air?
A. It constitutes 4 fifths of the atmosphere by
bulk, to 1 fifth of oxygen.
Q. Are these gases chemically combined in air?
A. It is thought not; but that air is a mere

mechanical admixture of oxygen and nitrogen.

Q. Are the proportions of these gases uniform in the atmosphere?

A. Yes, under all variations of height, depth, and other circumstances.

Q. How is this accounted for?

A. By the "law of the equable diffusion of gases." One gas does not interfere with the diffusion of another through space.

Q. Which is heavier, – oxygen or nitrogen?

A. Oxygen.

Q. Does the atmosphere contain no other gases?

A. Yes; a minute and slightly varying portion of carbonic acid, – of ammonia, – and of watery vapor.

Q. About what proportion of carbonic acid gas is the maximum?

A. 4-10000ths only.

Q. Has this importance in nature?

A. Yes; – it is essential to the vitality of vegetable growths.

Q. What effect has vegetable developement on the air?

A. Plants, during the day-time, take carbon from the air, and give out oxygen, – except while in bloom. At night, the process is reversed. –

Q. What effect has animal respiration upon air?

A. This process consumes the oxygen of the air, and increases the amount of its carbonic acid.

Q. What instrument was devised for the analysis of air and other gases?

A. The eudiometer.

Q. What is the principle of its use?

A. It is contrived to measure the volume of different gases mingled in its receiver, and the residue left after they are made to combine by the electric spark.

Q. May nitrogen and oxygen be made to combine explosively in this way?

A. Yes; in the proportion of 2½ volumes of oxygen to one of nitrogen gas.

Q. What compound is thus formed?

A. Nitric acid.

Q. Is this likely to occur in the total absence of moisture?

A. No. Nitric acid is one of those bodies which can hardly, if at all, exist in the insulated state; while water, or another base, will ensure its permanence.

Q. What is the composition of nitric acid

by equivalents?

A. It is $N.O_5$; one equivalent of nitrogen, = 14, to five of oxygen, = 40. Its combining number is therefore 54.

Q. What salt of nitric acid is most familiar and abundant?

A. Nitrate of potassa; commonly called nitre or salt-petre.

Q. What is the mode in which it is spontaneously or artificially produced?

A. By the contact for a length of time of masses containing potash, as the mortar of old buildings, &c, with organic remains, exposed to the air. Under those circumstances, the nascent nitrogen of decomposing animal substances unites with oxygen of the air, forming nitric acid, which then combines with potash, soda &c, forming nitrates.

Q. If no alkali be present, will the decomposition of animal matter yield nitric acid?

A. No; in the nitre beds, the potash &c act catalytically; predisposing the free elements to combine in that form.

Q. How may nitric acid be obtained from nitre or from the nitrate of soda?

A. By the addition of sulphuric acid; which,

by its stronger affinity for the alkaline base, decomposes the salt, and allows the nitric acid to be distilled over.

Q. If too little sulphuric acid be used, or the heat employed be great, what occurs?

A. Part of the nitric acid is decomposed, making the nitroso-nitric or fuming nitric acid, which gives off very pungent orange-colored fumes to the air.

Q. What is a common name for impure nitric acid?

A. Aqua fortis.

Q. Has pure nitric acid any color?

A. No.

Q. What will detect a mixture of sulphuric acid with it?

A. Chloride of barium; giving a precipitate of sulphate of baryta.

Q. What impurity will nitrate of silver solution detect?

A. Chlorine.

Q. How many definite compounds does nitric acid form with water?

A. Three.

Q. What is the specific gravity of the strongest acid?

A. – 1.52.

Q. What is the chief chemical value of nitric acid?

A. – Its oxidising power. Almost all the metals can deprive it of several equivalents of oxygen.

Q. Suppose, then, that nitric acid is poured upon ~~tin~~ or copper; what occurs?

A. Part of the nitric acid loses oxygen and is converted ~~given off in the form~~ into the of binoxide of nitrogen; the three separated equivalents of oxygen forming an oxide of the metal, which then forms a nitrate with the remaining acid.

Q. If this occur under exposure to the air, what appearance is presented?

A. ~~Red~~ Reddish orange fumes are given off; which are not seen if air is excluded.

Q. What are these fumes?

A. Hyponitrous or nitrous acid; formed by the union of the binoxide of nitrogen with oxygen of the air. These fumes are characteristic of the binoxide of nitrogen; which is itself colorless when pure.

Q. Name the five compounds of oxygen and nitrogen.

A. They are the Protoxide or Nitrous Oxide, $NO$, – the Deutoxide, Binoxide or Nitric Oxide, $NO_2$, – Hyponitrous acid, $NO_3$, – Nitrous acid, $NO_4$, – and Nitric acid, $NO_5$.

Q. By volume, in what corresponding proportions do Oxygen & Nitrogen combine?

A. The volume of oxygen is ½ where its equivalent is single. Thus, the protoxide consists of two volumes of nitrogen combined with one of oxygen; the binoxide, of equal volumes of the two; and so on.

Q. What salt of hyponitrous acid exists in a familiar medicinal preparation?

A. The hyponitrite of the oxide of ethyl; which is the active principle of the spirit. æth. nitr. dulc. or sweet spirits of nitre.

Q. How is nitrous oxide, or the protoxide of nitrogen best prepared?

A. By heating nitrate of ammonia in a retort. This salt, although a solid, is composed of the three gases, nitrogen, hydrogen and oxygen, with water; and is easily decomposed by heat.

Q. Explain the rationale of this decomposition.

A. One equivalent of ammonia contains one of nitrogen and three of hydrogen; one of nitric acid, contains one of nitrogen and five of oxygen; and one equivalent of water is always combined with the salt. After heating, the 2 equiv. of nitrogen are found united with 2 of oxygen, - making 2 equiv. of nitrous oxide; while the rest of the oxygen of the nitric acid unites with the hydrogen of the ammonia; leaving, in all, 4 equiv. of water.

Q. What are the physical properties of the protoxide of nitrogen?

A. It is a colorless, inodorous gas, of a sweet taste, which will support combustion more vividly than the air. It is absorbed by water, giving it a sweet taste.

Q. What is its most interesting property, however?

A. Its power to intoxicate when breathed. It has hence been called the "laughing gas", from the exhilaration it produces.

Q. Will nitrogen unite readily with the halogen bodies?

A. No; only when in the nascent state.

Q. What is the chief nitrogenous body so formed?

A. The explosive quadrochloride of nitrogen.

Q. To return to nitric acid: does it form any

insoluble salt?
A. No; all the nitrates are soluble.
Q. By what property, then, do you recognize a salt of nitric acid?
A. By its deflagrating, when thrown on burning charcoal.
Q. The salts of what other acid also deflagrate?
A. The chlorates.
Q. What other characteristic action of nitric acid do you remember?
A. It changes and destroys vegetable colors. Thus indigo, — by being first reddened & then bleached by nitric acid, is a test for it.
Q. What important metallic solvent does nitric acid form with muriatic?
A. The aqua regia, or nitro-muriatic acid; which is the best solvent for gold.
Q. To what does aqua regia owe its power of dissolving gold?
A. To the free chlorine which it contains; this being ~~evolved~~ by the mutual decomposition of the two acids when mingled.
Q. What is the composition of ammonia?

A. It is $NH_3$; three equivalents of Hydrogen, = 3, with one of Nitrogen, = 14; its combining number therefore being 17.

Q. By volume, how is it composed?

A. Of three volumes of Hydrogen, with one of nitrogen,— condensed into two.

Q. How may gaseous ammonia be prepared?

A. By mixing sal ammoniac, formerly called muriate of ammonia, (now chloride of ammonium), with quicklime.

Q. What apparatus must be used?

A. The mercurial pneumatic trough.

Q. Is ammonia absorbed by water?

A. Yes, most eagerly and rapidly. It has a most intense affinity for water.

Q. By virtue of this property, what effect has it upon animal tissues?

A. It is a very prompt and powerful caustic.

Q. What is its chemical reaction?

A. Strongly alkaline.

Q. Is this the case in the absence of water?

A. No; but a very minute portion of water will suffice to confer alkalinity upon it.

Q. How is this hypothetically explained?

A. It is supposed that the ammonia unites chem

-ically with an equivalent of water; converting $NH_3$ into ($NH_3 + HO$ or) $NH_4O$.

Q. What theoretical designation is then given to the $NH_4$ of the above formula?

A. It is called Ammonium; and is imagined to be a compound gaseous metal; whose oxide is thus brought into analogy of composition with the other alkalies.

Q. Does ammonia form definite neutral saline compounds with oxygen acids?

A. It does, — precisely as potassa & soda do.

Q. Does chlorohydric acid form salts with oxygen bases?

A. Not strictly; but the chlorine of the acid forms a chloride with the metal of a basic oxide, while its hydrogen forms water with the oxygen of the same, — giving a hydrated chloride. ($HCl + NaO$, giving $NaCl + HO$, for instance.)

Q. Can the same explanation be made to apply to the union of ammonia with muriatic acid?

A. Yes; — upon the theory above ~~st~~ stated, sal ammoniac is a hydrated chloride of ammonium.

Q. What observed fact confirms the hypothesis of the metallic nature of ammonium?

A. That, when a voltaic current is made to decompose an ammoniated salt in the presence of mercury, — an amalgam is formed; — which has been observed to be the case only when mercury was combined with some metallic substance.

Q. For the formation of an oxysalt of ammonia, then, what process is supposed necessary?

A. Dry ammonia, $NH_3$, is supposed to be, by the addition of water, converted into $NH_4O$, which combines with the acid used.

Q. What is amidogen?

A. A still simpler hypothetical radical, also never insulated, whose formula is $NH_2$.

Q. What are its compounds ~~called~~?

A. Amides.

Q. In what mercurial preparation does one of them exist?

A. White precipitate contains a bi-amide of mercury; being formed by the addition of ammonia to a solution of corrosive sublimate.

Q. What natural process affords ammonia spontaneously in considerable quantities?

A. Animal decomposition.

Q. What is the purest form of carbon found in nature?

A. The diamond.

Q. What are some other varieties of the same substance?

A. Charcoal, anthracite, plumbago, &c, in various degrees of purity.

Q. What is the origin of the coal-deposits so extensive in many countries?

A. The subterranean charring by natural process, ~~[illegible]~~ of the gigantic vegetation of the primeval world.

Q. What are the most interesting properties of charcoal?

A. Its power to absorb gases in large quantities, and to bleach and deodorize organic matters ~~percolating through it~~ in the liquid state. It is disinfectant and antiseptic.

Q. What are the chief oxides of carbon?

A. Carbonic oxide, $CO$, — Carbonic Acid, $CO_2$, and Oxalic acid, $C_2O_3$.

Q. Which of these is solid?

A. Oxalic acid. The others are gaseous.

Q. Can carbonic acid or oxide be breathed?

A. No. The latter is positively deleterious, — the

former destroys life only by the exclusion of oxygen from the lungs.

Q. Will either of these gases support combustion, in the ordinary sense?

A. No.

Q. Which of them will burn?

A. Carbonic oxide; with a blue flame,— as seen sometimes on coal fires, where the supply of oxygen is small.

Q. How may carbonic oxide be prepared?

A. By the action of sulphuric on oxalic acid.

Q. Give the rationale of this.

A. Oxalic acid, $C_2 O_3$, may be supposed to consist of Carbonic oxide & Carbonic acid combined. Sulphuric acid, by depriving it of water, essential to its existence, causes its resolution into those two gases,— the latter of which may be absorbed by limewater.

Q. How may carbonic acid be readily obtained?

A. By the action of sulphuric acid on a carbonate; such as chalk, marble &c.

Q. Is it a light, or a heavy gas?

A. So heavy, that it may be poured from a

glass like water; although it is gradually diffused on exposure.

Q. Has it a strong acid reaction & chemical effect?

A. No, — very feeble, — unless at low temperatures, by which its volatility is overcome.

Q. How may you know a salt in solution to be a carbonate?

A. By the addition of another acid, — which will cause effervescence.

Q. What is a good test for carbonic acid?

A. Limewater; which becomes turbid & milky in its presence. This may be shown by breathing into a cup of lime-water.

Q. Where does oxalic acid exist in nature?

A. In the sorrel, and some other plants, in the form of oxalates of potassa &c.

Q. What is the appearance of this acid?

A. It is white, and crystallizes in small needle-like crystals.

Q. Resembling what common medicine?

A. Epsom salts, or sulphate of magnesia.

Q. What is an easy mode of distinction between them?

A. By the taste. Oxalic acid is intensely sour.

Q. What are some chemical tests for it?

A. Oxalic acid gives a white precipitate with limewater, of the oxalate of lime; a white insoluble oxalate also with magnesia; and a yellow insoluble oxalate with salts of iron.

Q. What is the antidotal treatment for poisoning by oxalic acid?

A. The free administration of magnesia, lime or chalk.

Q. Is it a powerful poison?

A. Yes; of the corrosive kind.

Q. With what simple element does carbon form its most interesting binary compounds?

A. With hydrogen; giving a group of bodies of great & peculiar importance.

Q. What one property is almost universal amongst those bodies called carbo-hydrogens or hydro-carbons?

A. Inflammability: as both of its elements have a strong affinity for oxygen.

Q. What physical condition is common to many of these compounds, especially when associated

with oxygen?

A. The oleaginous condition.

Q. In what department of nature do they mostly originate?

A. In the vegetable & animal worlds.

Q. What hydrocarbon is the simplest in its composition?

A. $H_2C$, - called light carburetted hydrogen; whose equivalent is 7.12.

Q. Can this be artificially formed? *

A. No; for experiment, it must be obtained from some natural source; as for instance the bottom of ponds, - which emit it in bubbles when stirred.

Q. In what natural situations is the spontaneous evolution of light carburetted hydrogen an important fact?

A. In coal mines, - where it is called "fire-damp", - and causes very serious accidents by its explosion.

Q. Under what circumstances will it explode?

A. When mingled with air, and ignited.

Q. What admirable contrivance has been devised

to prevent such accidents in mines?

A. The "safety lamp" of Sir Humphrey Davy.

Q. What is the principle of this invention?

A. The lamp burns under a cylinder covered with *gauze* *wire*; which prevents flame from passing from the wick to the air without.

Q. *How* does the gauze wire prevent the passage of flame?

A. By ~~it~~ cooling ~~it~~ the inflamed gas down below the luminous & explosive temperature. Sir H. Davy was led to employ the wire gauze by observing the effect which metallic *tubes* had in cooling heated gas which passed through them, — and by considering that each pore of fine wire gauze ~~may be one~~ is in fact a small & short tube.

Q. This principle, of the cooling power of metallic tubes, is applied also in what other important apparatus?

A. In Dr Hare's Oxy-hydrogen blow pipe; in which oxygen & hydrogen are kept in separate reservoirs, and made to meet by

passing out in adjoining tubes, so as to burn in a combined jet.

~~Q. Although somewhat out of place, will you repeat some of the effects which may be produced by Dr Hare's compound blowpipe?~~

~~A. It gives a heat of very great intensity; capable of melting platinum, which is very refractory; — and of making lime vividly luminous, — as in what is called the Drummond light.~~

Q. Does light carburetted hydrogen exist in the ordinary gas used for illumination?

A. It does; mingled with other hydrocarbons, and some impurities.

Q. What other gas is most important in the coal-gas of our burners?

A. Olefiant gas.

Q. What is its composition?

A. $C_4H_4$; being an instance of an exceptional mode of definite combination, — in which two atoms of each element are supposed to be united in one of the compound.

Q. How may olefiant gas be prepared?

A. By mixing alcohol with 3 times its bulk

of sulphuric acid, and applying heat.

Q. Does the flame of this gas give out more light than the dicarburet of hydrogen?

A. Yes; as it contains twice as much carbon. The luminosity of flame is owing to the presence of unconsumed solid particles.

Q. How many volumes of oxygen will combine in combustion with the elements of one of olefiant gas?

A. 3 volumes; producing carbonic acid & water; which are also the results of the combustion of light carburetted hydrogen.

Q. What are some of the properties of olefiant gas?

A. It is colorless, — lighter than air, and absorbed to a small amount by water.

Q. When coal gas is made by heating bituminous coal red hot in iron retorts, what are the chief educts which pass over?

A. Light carburetted hydrogen, olefiant gas, carbonic oxide & acid, empyreumatic matter, ammonia, sulphuretted hydrogen, and a small amount of cyanogen.

Q. Are most of these impurities readily re-moved?

A. Yes; some of them are condensed in passing through vertical pipes, while others are absorbed by limewater &c.

Q. What is the Specific gravity of a good illuminating gas?

A. .62. The heavier it is, the more luminous its flame.

Q. Does the amount of oxygen supplied affect the truth of this statement?

A. Yes; with a deficient supply of oxygen a carbonaceous gas burns with smoke; while a very full supply consumes it with but little light.

Q. Is not oil of turpentine or camphene a carbohydrogen?

A. It is; $C_5H_4$.

Q. What familiar solid substance has a similar composition?

A. Caoutchouc; being a condensed volatile oil.

Q. What is a compound of carbon and nitrogen?

A. Cyanogen; $C_2N$.

Q. What name expresses its composition?

A. Bicarburet of nitrogen.

Q. Why is it called in preference by a name which does not denote its elements?

A. Because it is a <u>compound</u> <u>radical</u>, and

combines independently with simple bodies, as though it were an element.

Q. What is the derivation of the word Cyanogen?

A. From a greek word which signifies ~~purple~~ blue; from ~~the color of its flame.~~ Prussian Blue, which is one of its compounds.

Q. What are the products of its combustion?

A. Carbonic acid and nitrogen.

Q. May cyanogen be condensed into a liquid?

A. Yes.

Q. Will it combine with the metals?

A. Yes; forming cyanides, analogous to the haloid chlorides &c.

Q. Name one of these which is used medicinally?

A. Cyanide of Potassium.

Q. What important compound does cyanogen form with hydrogen?

A. Cyanohydric or hydrocyanic acid.

Q. Give the familiar name of this substance.

A. Prussic acid; one of the most powerful of known poisons.

Q. Can it be made by direct union of its elements?

A. Yes, by means of the electric spark.
Q. What is a readier mode of preparing it?
A. By the action of sulphuric acid on the cyanide of potassium.
Q. What are the properties of hydrocyanic acid?
A. It is a liquid, very volatile, with a peculiar odor.
Q. With what is it generally associated in nature?
A. With a volatile & fragrant oil, called the oil of bitter almonds.
Q. From what natural sources may prussic acid be obtained?
A. From the leaves & kernel of the peach, - & from the cherry laurel, wild cherry leaves, bark & fruit &c,
Q. What is its composition by equivalents?
A. HCy; or $HC_2N$.
Q. Does it exist as a natural product in the vegetable organisms above mentioned?
A. No; but the proximate materials exist there together, which readily form it with warmth & moisture.

Q. What are these materials?
A. Amygdalin & Emulsin; compound bodies, the latter of which acts as a ferment to the other, being nitrogenous and easily undergoing decomposition.
Q. Is amygdalin poisonous when alone?
A. No; nor is emulsin; but the two together by mutual reaction produce the prussic acid & oil of bitter almonds.
Q. Give an illustration of the power of hydrocyanic acid to destroy life.
A. One drop on the tongue of a dog or a cat will cause its death in a few seconds. It is not safe to inhale the vapor of the acid when undiluted.
Q. What is the strength of the officinal prussic acid?
A. It is diluted with 22½ times its weight of water.
Q. Is there any certain or prompt antidote for its effects on the system?
A. No; it destroys life usually too soon for remedies to be applied. Cold affusion is highly recommended. Chlorine, and ammonia

are thought to be of some use; and recently the administration of a persalt of iron, followed by an alkaline carbonate, has been proposed.

Q. What metal forms a white precipitate with cyanogen?

A. Silver; giving the white cyanide of silver.

Q. How is this distinguishable from chloride of silver?

A. The cyanide is not very soluble in ammonia; and will give out the odor of hydrocyanic acid when nitric acid is added to it.

Q. What, however, is a more accurate test?

A. The formation of prussian blue on the addition of a persalt of iron and the carbonate of potassa.

Q. Is there any still more certain mode of testing for prussic acid?

A. Yes. add to the suspected liquid a solution of sulphuret of ammonium; if cyanogen in any form be present, the sulphocyanide of ammonium will be produced; and this, on the addition of a persalt of iron, will give the sulphocyanide of iron, which is a blood red precipitate.

Q. Is cyanogen ever spontaneously formed except in the plants previously named?

A. Yes; the decomposition of animal matter in the presence of an alkali may yield it.

Q. By what similar artificial process may we produce it?

A. By heating bullock's blood or some analogous nitrogenous substance with an alkali, — cyanogen is formed and combines with the metal of the alkali, forming a cyanide.

Q. Can you name still another process for the formation of cyanogen?

A. It may be made by passing nitrogen gas over carbon made red hot, and moistened with solution of potassa. A cyanide of potassium results.

Q. When cyanogen gas is passed into water, what occurs?

A. A solution is formed, which is decomposed into cyanic acid, — CyO.

Q. Can this acid be isolated entirely?

A. No; it cannot exist without water or some other base.

Q. What is isomeric with cyanic acid?

A. Fulminic acid; which is also $CyO$, or $C_2NO$.

Q. Are cyanic & fulminic acids mutually convertible?

A. No.

Q. How is fulminic acid made.

A. When alcohol or ether is decomposed by nitric acid in the presence of mercury, the carbon of the alcohol or ether with the nitrogen and part of the oxygen of the nitric acid forms fulminic acid, which then unites with the oxide of mercury.

Q. What striking property have the fulminates of mercury and silver?

A. They explode violently under percussion.

Q. Will the cyanates of the same oxides do this?

A. No.

Q. Will cyanic acid unite with ammonia?

A. Yes, in the presence of water.

Q. What organic product is identical with the cyanate of ammonia?

A. Urea.

Q. What other acid closely resembles cyanic acid in composition?

A. Cyanuric acid; differing only in the number of atoms of water it contains.

Q. Will prussic acid remain long in solution without decomposition?

A. No; it is slowly converted into formic acid and ammonia.

Q. What is the composition of formic acid?

A. It is the teroxide of formyl; $C_2H.O_3$.

Q. How is Sulphur found in nature?

A. In combination with several of the metals, and also native, or uncombined.

Q. What is a compound of sulphur with an electropositive element called?

A. a sulphuret or sulphide.

Q. Give some of the properties of sulphur.

A. It is a yellow, brittle solid, with a slight odor, conducting heat and electricity very imperfectly. It melts at 320° Fahr. If heated to 425°, ~~in~~ water, it becomes semi-solid, like gum elastic, at a still higher temperature it vaporizes, and will readily take fire in the open air, ~~burning~~ with a blue flame.

Q. Is it crystallizable?

A. Yes, in right-angled prisms. It is, however,

dimorphous; — being capable of assuming another form under some circumstances, — as when the crystals are kept for a time.

Q. Can sulpher be sublimed?

A. Yes; the deposit being called "flowers of sulphur". It is crystalline.

Q. What results from the combustion of sulpher in the air?

A. Sulpherous acid, $SO_2$; the equivalent of which therefore is 32.

Q. Will this acid gas redden litmus paper?

A. Yes, but it afterwards bleaches it, from its affinity for oxygen.

Q. Is the bleaching power of sulpherous acid sufficient to ~~be~~ of importance?

A. It is; being capable of frequent practical application.

Q. How else may $SO_2$ be prepared?

A. By deoxidizing sulphuric acid by a metal, — as mercury, for instance.

Q. What is the composition of sulphuric acid?

A. $SO_3$. Mercury will deprive it of one atom of oxygen, leaving $SO_2$.

Q. Can sulpherous acid be liquefied?

A. Yes, by the use of a bent tube &c, under a

pressure of 2 atmospheres.
Q. What is a simple process for obtaining sulphuric acid?
A. The exposure to heat of green vitriol; which is a sulphate of the protoxide of iron.
Q. Can sulphuric acid be brought into the anhydrous state?
A. Yes; it is then an asbestos-like solid.
Q. Has it much affinity for water?
A. Probably the greatest of all known substances. The anhydrous acid fumes in the air, from rapid union with moisture.
Q. What is the common name of sulphuric acid?
A. Oil of vitriol.
Q What special name is given to the acid prepared from sulphate of iron?
A. It is called the Nordhausen acid.
Q. What proportion of water does this contain?
A. One equivalent.
Q ~~How~~ much has ordinary oil of vitriol?
A Two equivalents of water.

Q. Will dry sulphuric acid redden vegetable blues, or combine with metallic oxides?
A. No; the presence of water is necessary to the development of its chemical powers.
Q. Is sulphuric acid of importance in the arts?
A. Yes, very great.
Q. How is it usually prepared?
A. By burning sulphur with nitre, & allowing the gases evolved to pass, with vapor of water, into a leaden chamber containing water.
Q. What gases are evolved in the combustion of sulphur & nitrate of potash together?
A. The nitric acid gives oxygen to the sulphur, making sulphurous acid, —being itself converted into nitrous or hyponitrous acid. These gases pass together into the leaden chamber.
Q. What change then occurs?
A. By union with vapor of water, a white crystalline solid is produced, which falls into the water at the bottom. This solid is then decomposed into sulphuric acid, binoxide of nitrogen, and water. The binoxide of nitrogen escapes & is reoxidised. The solution of sulphuric acid thus formed is

then concentrated by redistillation.
Q. What is the boiling point of Sulphuric acid?
A. 652° Fahrenheit.
Q What is the specific gravity of Sulphuric acid?
A. 1.85 when it contains one equivalent of water.
Q. How many definite compounds does $SO_3$ make with water?
A. Three.
Q. Is it a strong acid?
A. Very; both chemically and in taste.
Q. What is its chemical test?
A. Chloride of barium; forming with it the very insoluble sulphate of baryta.
Q. What other oxygen acids does sulphur form?
A. Hyposulphurous and hyposulphuric.
Q What is the composition of the latter?
A. $S_2O_5$.
Q. Of Hyposulphurous acid?
A. $S_2O_2$.
Q. Can these be isolated?
A. The former only, with difficulty and

instability.

Q. Why is sulphur called an amphigen element by Prof. Hare & others?

A. Because it produces compounds which unite with each other as acid and base. For instance, the sulphuret of hydrogen is a sulphur acid, — while the sulphurets of potassium & sodium are sulphur bases, or basic sulphurets.

Q. Will a sulphur acid unite with an oxygen base?

A. No; only with an alkaline sulphuret.

Q. What other sulphur acid is there besides the sulphydric?

A. Sulphocarbonic; which is the bisulphuret of carbon.

Q. Give the formula for sulphuretted hydrogen.

A. HS.

Q. How does it occur in nature?

A. As a frequent result of organic decomposition, — especially animal. The odor of rotten eggs &c is owing to its presence.

Q. How is it easily prepared in the Labora-
-tory?

A. By the action of sulphuric acid on sulphuret of iron.

Q. Explain the reaction which occurs.

A. It differs from the process for preparing pure hydrogen, merely by the presence of the sulphur of the sulphuret, — which combines with the hydrogen as it is given off.

Q. Has sulphuretted hydrogen gas any color?

A. No. Its characteristic property is its disagreeable odor.

Q. Is it condensible into a liquid?

A. Yes, — and this may even be froze solid under pressure & cold.

Q. Is it inflammable?

A. Yes; it burns with a blue flame.

Q. Producing what results?

A. Water, and sulphurous acid.

Q. Is sulphuretted hydrogen absorbed by water?

A. Yes, — and the hydrogen is afterwards given off by degrees, precipitating the sulphur, in the form called "lac sulphuris."

Q. What reaction occurs between sulphuretted hydrogen and ammonia?

A. A hydrated sulphuret of ammonium is formed, — analogous to the chloride of ammonium formed by chlorohydric acid.

Q. What important relation does sulphydric acid bear to some of the metals?

A. It precipitates all those designated as metals proper from their solutions; thus affording a most valuable test for metals of this class.

Q. What is an instance of this mode of testing?

A. The black precipitate formed by throwing a jet of sulphuretted hydrogen upon paper marked with a solution of acetate of lead.

Q. What qualification however should be remembered to the above statement as to the metals proper?

A. Some of them are not precipitated by free sulphuretted hydrogen alone, but require the addition of an alkali or alkaline metal; as in the form of sulphuret of ammonium or of potassium. This is

the case with iron, for example.

Q. What metal forms the <u>most delicate</u> test for sulphydric acid?

A. Bismuth.

Q, Is there a bisulphuret of hydrogen?

A, Yes; $HS_2$, — an oily liquid, analogous to the peroxide of hydrogen, — as the protosulphuret is chemically analogous to water.

Q. By passing the vapor of sulphur over red hot charcoal, what compound do we form?

A. The bisulphuret of carbon, — a sulphur acid, called sulphocarbonic; it is a liquid, and combines with sulphurets of the alkaline metals, making sulphur salts.

Q, What is sulphocyanogen?

A, A complex compound radical, $CyS_2$, — the bisulphuret of cyanogen. ~~It is also called sulphocy~~ It forms an interesting series of compounds.

Q. For what has it been stated to be an important test?

A. For prussic acid, — in connexion with a persalt of iron.—

Q. Will sulphur combine with the halogen bodies?
A. Yes; there are chlorides, iodides and bromides of sulphur.—
Q. What are two simple elements somewhat analogous to sulphur?
A. Selenium and Tellurium.
Q. Why do the names of these substances terminate in <u>um</u>?
A. To indicate their similarity in some respects to the metals.
Q. What is the color of selenium?
A. Reddish brown.
Q. What odor does it give out when heated?
A. That of horseradish.
Q. Does it combine with oxygen?
A. Yes; forming the protoxide, $SeO$,- Selenious acid, $SeO_2$, & Selenic acid, analogous to sulphuric,— $SeO_3$.
Q. Will hydrogen unite with selenium or tellurium?
A. Yes; producing seleniuretted or telluretted hydrogen.
Q. How is phosphorus found diffused in Nature?

A. Chiefly in the form of phosphates, in soils, plants, & the bones & neurine of animals.

Q. How may phosphorus be obtained from bones?

A. By calcining them, and adding sulphuric acid; after which the superphosphate of lime remaining is heated with carbon, which deoxidizes the phosphorus & leaves it pure.

Q. What is the appearance of pure phosphorus?

A. It is amber-colored, waxy, and translucent.

Q. At what temperature does it melt?

A. 108° Fahr.

Q. Does it retain its color on exposure?

A. It becomes much redder.

Q. Has it much affinity for oxygen?

A. Yes, - very great; so that it burns slowly in the air at common temperatures, and is very easily inflamed; by friction for instance.

Q. How is it usually kept, for safety?

A. In water, or some other ~~incombus~~ substance which does not afford it oxygen.

Q What is the result of the combustion of phosphorus in air or oxygen?

A. Phosphoric acid, $PO_5$.

Q. Can this acid exist in the anhydrous state?
~~Q. Can~~
A. Yes; if prepared by combustion of phosphorus in dry air, it is anhydrous.
Q. Does it display much affinity for water?
A. Yes; so great as to produce a fizzing sound when dissolving.
Q. When prepared by decomposition of a phosphate, — how many equivalents of water does it retain?
A. Three.
Q. With how many equivalents of an alkaline base does ordinary phosphoric acid combine?
A. With three; being hence called a <u>tri-basic</u> or <u>polybasic</u> acid.
Q. Does water then simply follow the law which applies to other bases in this case?
A. Precisely. Salts may be formed containing one or two equivalents of an alkali and two or one of water, united with one of phosphoric acid. There are thus three different phosphates of soda; one having 3 equiv. of soda, another two, — and the third but one; the deficiency being supplied by water.
Q. Is the phosphate containing 3 atoms of soda properly called a <u>sub</u>-phosphate?

A. No; it is neutral in reaction; as phosphoric acid requires 3 equiv. of base to neutralise it.
Q. Are there several other acids which are polybasic?
A. Yes; acetic & cyanuric acids are tribasic; citric & tartaric are bi-basic.
Q. May different bases unite with the acid in any of these cases?
A. Yes; tartar emetic, for example, is the tartrate of antimony and potassa: Rochelle salt the tartrate of potassa & soda.
Q. When water takes the place of one equivalent of base, - what prefix has become customary?
A. It is usually called a bisalt; as cream of tartar is termed the bitartrate of potassa; being really the tartrate of potassa & water.
Q. What effect has heat on the tribasic phosphoric acid, or such of its salts as contain but one atom of a fixed base?
A. A certain degree of heat will drive off one atom of water, or other volatile base, - while a high heat will drive off two equivalents; leaving in the first case a bi-basic, & in the second monobasic phosphoric acid.

Q. What other names have been applied to these modifications of the acid respectively?
A. Metaphosphoric and pyrophosphoric acids. The monobasic is also called glacial phosphoric acid.
Q. Do the salts which these acids form with the same base display the same, or different chemical reactions?
A. There are some positive differences between them; as for instance in the color & properties of the precipitate they make with silver.
Q. Does the combination of 3 equivalents of water with an acid prevent its action upon vegetable blues?
A. No.
Q. Does phosphorus unite with Chlorine, Iodine & Bromine?
A. Yes.
Q. Will it combine with hydrogen?
A. It will, — forming either phosphoretted or perphosphoretted hydrogen.
Q. How may phosphoretted hydrogen be prepared?
A. Either by applying heat to hydrated phosphorous acid, or by heating phosphorus with water and an alkali.
Q. When prepared in the latter mode, what curious phenomenon occurs?
A. The gas, as it developes, takes fire spontaneously.

exploding into a succession of beautiful rings or wreaths of smoke.

Q. What is the odor of phosphoretted hydrogen?

A. Alliaceous.

Q. What is the composition of phosphorous acid?

A. It is $PO_3$.

Q. Does silicon ever occur uncombined, in nature?

A. No.

Q. In what form is it very abundant?

A. In that of its teroxide, - called silex, silica, or silicic acid.

Q. What familiar substances consist of this in different degrees of purity?

A. Flint, sand, rock-crystal &c, — the latter of which is the purest.

Q. Is silex fusible?

A. Only by a heat as high as that of the oxy-hydrogen blow-pipe.

Q. Does it combine definitely with bases as an acid?

A. Yes; forming silicates, with either one or two bases; for example feldspar, which is the silicate of alumina & potassa.

Q. Will silicic acid dissolve in water?

A. No; although in very ~~hot~~ water it will dis-

-appear & thus seem to be dissolved, - after first presenting a gelatinous consistence. If dried, however, it is left in a hard, gritty state, no longer capable of being acted on by water or other acids. Hot springs, as those of Iceland, contain silica in this suspended condition.

Q. Are the silicates of the alkalies soluble?

A. Yes; the silicate of potassa, and the silicate of soda are each soluble in water; but the double silicates are insoluble.

Q. What is the nature of most of these double silicates?

A. They have the properties of glass; being transparent & uncrystallizable.

Q. What is flint glass, for instance?

A. A silicate of potassa & soda, containing also some oxide of lead, and a portion of other metallic oxides.

Q. How may pure silicon be obtained from silica?

A. By heating it strongly with potassium, which deprives it of oxygen.

Q. To what other acid is silicic acid most analogous in its chemical relations?

A. Sulphuric acid.
Q. Will silicic acid decompose alkaline carbonates in solution?
A. Yes, — as silicic acid is stronger than carbonic at ordinary temperatures.
Q. What is the chief native compound of Boron?
~~A. The biborate of soda, called Borax, used in the arts & in medicine.~~
~~Q. What is the acid contained in this salt?~~
A. Boracic acid; which is given off in vapor from the soil in some parts of ~~found most abundantly in~~ Tuscany.
Q. What is the composition of this acid?
A. 3 equivalents of Oxygen to 1 of Boron.
Q. What is its most important salt?
A. The biborate of soda, or borax; which is used in the arts and in medicine.
Q. Is boracic acid a strong, or a feeble acid?
A. It is feeble.
Q. What peculiarity ~~attends~~ its action on vegetable blues?
A. It produces a wine-red with litmus; while other acids produce an onion-skin red.

(Next, the metals.)

# Continuation of Chemical Catechism.

# The metals.

Q. What physical properties chiefly characterise metals?

A. A lustrous appearance, weight, opacity, and power to conduct heat and electricity.

Q. How do they compare with other bodies in their power to reflect light and heat?

A. They are the ~~good~~ best reflectors, especially when polished.

Q. Are they good or bad radiators of heat?

A. Bad; and, for the same reason, slow to absorb heat.

Q. What is their electro-chemical relation to other bodies?

A. They are electro-positive, as is shown in the electrolysis of their compounds.

Q. What is the nature of their texture?

A. Crystalline, usually; most metals assuming under some circumstances the form of the cube, or some form derived from it.

Q. In what properties is great variety ob-

-served among them the metals?

A. In hardness, malleability, ductility and tenacity.

Q. What metal is the most malleable?

A. Gold.

Q. Which is the most ductile? Platinum.

A. Iron. The tenacity of iron wire is also the greatest; a wire of twice the diameter of a hair being able to sustain the weight of a man.

Q. What are the lightest of the metals?

A. Potassium and sodium; which float on water.

Q. Which is the heaviest of those in common use?

A. Gold.

Q. Is gold leaf transparent?

A. No; but when finely beaten out it appears to be translucent, the light passing through minute pores of the metal.

Q. Where do the metals abound in nature?

A. In the rocky crust of the earth, in the form of oxides, sulphurets, and various haloid and amphigen salts.

Q. What is the average specific gravity of the earth?

A. 5.6.

Q. Repeat the definition of haloid and amphigen salts.

A. A haloid salt is a compound of a metal with one of the halogen bodies, chlorine, iodine, bromine, fluorine, — or with a compound radical analogous to them, as Cyanogen. An amphigen salt is composed of an acid and a base, which contain each the same electronegative element, as oxygen for example.

Q. May the same metal form both acid and basic oxides, sulphurets &c?

A. Yes; the protoxide & sesquioxide of iron are basic, while the teroxide is denominated ferric acid.

Q. May not the same substance display both acid & basic properties, under different circumstances?

A. Yes; alumina is basic with acids, yet combines (with some bases)[2] (as an acid.)[1]

Q. Will the same acid combine with an oxide in different proportions, forming different salts?

A. Yes; but rather as an exception to the rule.

Q. Where a metal has several oxides, what rule prevails as to their union with the same acid?

A. That the number of equivalents of acid which unite with a base, is ~~[illegible]~~ in proportion

to the number of equivalents of oxygen in the base.

Q. Give an example.

A. The protoxide of iron, $FeO$, combines with one of sulphuric acid, forming the protosulphate of iron; while the sesquioxide, $Fe_2O_3$, containing three equivalents of oxygen, unites with three of sulphuric acid, to form the persulphate.

Q. What is a double salt?

A. A compound of two salts.

Q. Will either haloid or amphigen salts unite to form such compounds?

A. Yes. Alum is an interesting example of the latter variety; being a compound of the sulphate of alumina with the sulphate of potassa.

Q. What is meant by isomorphism?

A. Two bodies are isomorphous which crystallise similarly; the term being derived from words which mean like in form.

Q. Does similarity in chemical and other properties accompany similarity in form?

A. Yes, — with some limitation. In many compounds an element may be replaced or substituted by an isomorphous body, with little change in its properties.

Q. Illustrate this by the example of alum.

A. In this salt, the sulphate of alumina may be replaced by the sulphate of the sesquioxide of iron, — and the sulphate of potassa by that of ammonia; without much alteration of the properties of the compound.

Q. When two metals are isomorphous, are their oxides, chlorides &c usually so also?

A. Yes; and the assertion may be extended to their various salts.

Q. May not some distinctive test be found, however, in each case?

A. Yes.

Q. Name a few of what may be called isomorphous groups.

A. 1. The four halogen elements. 2. Sulphur, Selenium and Tellurium. 3. Phosphorus, Antimony, and Arsenic. 4. Barium, Strontium and Lead. 5. The alkaline metals, Potassium, Sodium, Lithium and Ammonium. 6. Magnesium, Manganese, and Iron. 7. Cobalt, Nickel, Copper, ~~and~~ Zinc, and Cadmium.

Q. How may the metals be classified with convenience?

A. Into four groups, as follows. 1. Metals of the

alkalies. 2. Metals of the Alkaline Earths. 3. Metals of the Earths 4. Metals proper.

## The Alkalies.

Q. What are the four alkalies, whose metals form the first of these groups?

A. Potassa, Soda, Lithia, and Ammonia.

Q. What are the metals of which these are oxides?

A. Potassium, Sodium, Lithium and Ammonium.

Q. Which of these is complex and hypothetical?

A. Ammonium; incapable of isolation, - supposed to be composed of 1 equiv. of Nitrogen and 4 of hydrogen.

Q. How may potassium, sodium and lithium be obtained from their alkalies?

A. Davy first separated them by the decomposing power of a strong voltaic battery. Also, by heating either of the fixed alkalies strongly with finely divided carbon; the latter takes oxygen to form carbonic acid, and the metal is reduced.

Q. Will this process apply to the reduction of most metals from their oxides?

A. Yes. The carbon may be obtained by calcining an organic salt, - as cream of tartar, - which contains carbon to a considerable amount.

Q. What is the appearance of pure potassium?

A. It is soft, with a waxy consistence and lustre

resembling steel, which tarnishes on exposure to air. At 32° it is brittle and hard; at 150° it ~~becomes~~ is liquified; and if then squeezed between two plates of glass, it becomes malleable.

Q. Has it a strong affinity for oxygen?

A. Very; decomposing any compound containing it by its superior attraction.

Q. Is potassium inflammable?

A. Yes; when thrown upon water it burns explosively, by the deoxidation of the water, and the ~~inflammation~~ of its hydrogen. The flame thus produced is rosecolored.

Q. Is this rosecolored flame characteristic of potassium?

A. It is; the metal, or any of its compounds, when added to alcohol, will cause that substance to burn with a "rosy hue" when set on fire.

Q. How may potassium be preserved from the oxidizing influence of the air?

A. By immersion in naptha, which is a carbo-hydrogen.

Q. What is the equivalent or combining ~~number of~~ potassium?

A. 40.

Q. What is its symbol?

A. K; from Kali, the root of the word alkali.

Q. What proportion of oxygen does potassa contain?

A. One equivalent; being the protoxide, KO; its combining number is therefore 48.

Q. Is there any other oxide of potassium?

A. Yes, the teroxide, $KO_3$; formed by burning potassa ~~with~~ a high heat.

Q. How does potassa compare with other bases in its power of neutralising acids?

A. It is the strongest of the alkalies; being capable of combining with all the acids, and of separating them generally from other oxides.

Q. Does it occur frequently in nature?

A. Yes, - in rocks, soils, plants and trees, and in the bodies of animals, in the form of various salts.

Q. From which of these sources is it generally procured?

A. From plants, by reducing them to ashes.

Ley is an impure solution of ~~potash and its carbonate of~~ potash and its carbonate.

Q. How may the purest potash be obtained?

A. By burning the tartrate of potassa, then adding water, and afterwards lime, which takes

the carbonic acid left from the decomposition of the tartrate.

Q. Has potassa much affinity for carbonic acid?

A. Yes; it will take it readily from the air when exposed.

Q. In what form is it usually kept?

A. In what is called potassa fusa or vegetable caustic; being melted and poured into moulds.

Q. Is potassa fusa anhydrous?

A. No; it is a hydrate, containing at least one equivalent of water.

Q. May potassa be obtained perfectly free from water?

A. Only by the union of pure potassium with dry oxygen gas.

Q. Has the hydrate a tendency to absorb more water?

A. Yes; so that it deliquesces, or dissolves and liquefies, on exposure to the air.

Q. What are the properties of metallic sodium?

A. It is similar to potassium except that it is whiter; it can be welded, like iron and

platinum; and it gives a yellow hue to the flame of alcohol.

Q. Does it oxidize when thrown upon water?

A. It does, although less rapidly than potassium; no combustion ensuing unless under very favorable circumstances. A solution of nitric acid will cause it to take fire, from more rapid oxygenation.

Q. Is the yellow hue given to the flame of burning alcohol characteristic of all the compounds of sodium?

A. Yes.

Q. Which of these compounds is the most important?

A. ~~Soda,~~ The alkali, soda; $NaO$; the equivalent of which is 32.

Q. Is this closely analogous to potassa in properties and chemical relations?

A. Yes. Potassa is generally the strongest base, however.

Q. Is there any higher oxide of sodium?

A. There is a sesquioxide, made by burning soda.

Q. Will the halogen elements combine readily with potassium or sodium?

A. Yes; forming the true haloid salts; of

which the chloride of sodium and iodide of potassium are the most interesting.

Q. Will muriatic acid form a muriate, properly speaking, with an alkali?

A. No; chlorohydric acid with potassa, for instance, forms a hydrated chloride of potassium; its hydrogen uniting with the oxygen of the potassa to form water.

Q. Is this supposed to be true also in the case of the volatile alkali, ammonia?

A. Yes; a chloride of ammonium is supposed to be formed; as in the production of what is called sal ammoniac.

Q. What proportion of chloride of sodium exists in the water of the ocean?

A. 27/10 per cent.

Q. Where else is it always to be found?

A. In the tissues of all plants and all animals; being an essential nutriment to organised beings.

Q From what source is soda chiefly obtained?

A. From the ashes of marine plants.

~~Q. Is soda, like potassa, a powerful caustic?~~

~~A. It is, but inferior to potassa in this respect.~~

~~Q. What are the chemical tests of alkalinity?~~

~~A. Besides the power of neutralizing acids, alkalies change vegetable blues of litmus to green, and the yellow of turmeric to brown.~~

Q. Do potassium and sodium combine readily with sulphur?

A. Yes; there are 5 definite sulphurets of potassium, and several of sodium.

Q. What reaction occurs between the sulphuret of potassium and chlorohydric acid?

A. Chloride of potassium and sulphuretted hydrogen result, – with the precipitation of part of the sulphur: the name of lac sulphuris being applied to this precipitate.

Q. What further chemical interest have the proto sul-phurets of potassium and sodium?

A. They are sulphur bases; uniting with sulph-ydric, sulphocarbonic or other sulphur acids, to form true amphigen salts.

Q. ~~To this base to~~ How may the Cyanide of potassium be produced?

A. By heating some nitrogenous organic matter, as dried blood, for instance, – with potassa.

Q. What is the nature of the salts called in commerce

prussiates of potassa?

A. They are compounds of the cyanide of potassium with the two cyanides of iron, $Fe\,Cy_3$ and $Fe_2\,Cy_3$.

Q. What names are given to these cyanides of iron respectively?

A. $Fe\,Cy_3$ is called Ferrocyanogen, & $Fe_2\,Cy_3$, Ferri-cyanogen. They appear to act as compound radicals; or at least to produce compounds totally different from any which their elements can form in any other mode of combination.

Q. What is the yellow prussiate of potassa, so called?

A. It is a compound of two equivalents of the cyanide of potassium with one of Ferrocyanogen; $2K\,Cy + Fe\,Cy_3 + 3HO$, when in the crystalline form.

Q. What is the red prussiate of potash?

A. It is a compound of three equivalents of cyanide of potassium with one of Ferri-cyanogen; $3K\,Cy + Fe_2\,Cy_3$.

Q. Are these salts poisonous?

A. No.

Q. What is the effect of acids, sulphuric for example, upon cyanide of potassium?

A. They develope cyanohydric acid, by the decomposition of water, & the formation of an oxy-salt with the potassium.

Q. What is the advantage of cyanide of potassium as a medicinal preparation?

A. It is thought to be safer than the pure hydro-cyanic acid for administration.

Q. What striking precipitate is formed by the addition of a per-salt of iron to the yellow prussiate of potash, so called?

A. Prussian blue.

Q. How is the pigment called "Turnbull's blue" produced?

A. By the addition of a proto-salt of iron to the red prussiate of potash, - i.e. the Ferri-cyanide of the cyanide of potassium.

Q. What is the composition of Prussian blue?

A. It is a compound of ferrocyanogen with the proto-cyanide of iron.

Q. What is Turnbull's blue?

A. A compound of ferri-cyanogen with the same cyanide of iron. Chemists differ as to the precise formulae in both of these cases.

Q. What are the most familiar of the oxy-salts of soda & potassa?

A. Their carbonates. They are obtained in this form from the ashes of plants.

Q. Do solutions of these alkalies display much affinity for carbonic acid?

A. Yes; absorbing it rapidly. Liquor potassae is used for this purpose in organic analysis.

Q. How may the purest carbonate of potassa be prepared?

A. By burning cream of tartar. The tartaric acid is converted into carbonic.

Q. Is the anhydrous salt of tartar, or carbonate of potassa, thus formed, crystalline?

A. No, – it is granular. To crystallize, it re-quires two equivalents of water.

Q. When exposed to the air, what change does the carbonate of potash undergo?

A. It deliquesces.

Q. Is the same true of the carbonate of soda?

A. No; carbonate of soda effloresces, from the loss of its water of crystallization; of which it has 10 equivalents.

Q. Will these carbonates absorb or combine with any additional carbonic acid?

A. Yes, – one equivalent, – making respectively the bicarbonate of potassa and the bicarbonate of soda.

Q. In these bicarbonates, is not water an important

ingredient?

A. Yes; one equivalent of water is essential, to combine with the added equivalent of carbonic acid; so that a ~~bicarbonate~~ is really a double salt; a salt of the fixed base combined with a salt of water., ~~chemically speaking~~

~~Q. Does the sulphate of potassa contain any constituent water?~~

~~A. No.~~

Q. With what ~~the~~ other salt is the sulphate of potassa isomorphous?

A. With the chromate of potassa; chrystallizing in 6-sided prisms.

Q. What is the common name of the sulphate of soda?

A. Glauber's salt.

Q. How much water does this contain, when chrystallized?

A. 10 equivalents.

Q. May these all be driven off by heat?

A. all but one equivalent, - which remains so long as the salt remains undecomposed, - and is hence called constitutional or essential to the salt.

Q. Does the sulphate of potassa deliquesce, like the carbonate?

A. It does; while the sulphate of soda effloresces.

Q. Can bisulphates of potassa and soda likewise

be formed?

A. Yes; containing each an equivalent of water corresponding with the added one of acid.

Q. May this equivalent of water be replaced by another base, — forming a true double salt?

A. Yes; by ammonia, for instance.

Q. How are the nitrates of potassa and soda sometimes spontaneously formed?

A. By the mingling of animal remains with alkaline soil, or the ruins of old walls &c. The nitrogen of the organic substances is oxidized, and the resulting nitric acid unites with the alkalies present.

Q. What is nitre, or saltpetre?

A. Nitrate of potassa; $KO + NO_5$.

Q. Of what is gunpowder composed?

A. Of nitre, sulphur and charcoal.

Q. What are the results of its combustion or explosion?

A. Nitrogen & carbonic acid gases, and sulphuret of potassium.

Q. Will the nitrate of soda form a similar compound?

A. Yes; as it, like all nitrates, deflagrates with charcoal.

Q. Does the nitrate of soda contain water?

A. No; the nitrate of potassa, however, does, — as

does also ~~the~~ carbonate ~~sulphate~~ of potassa.

Q. What familiar use is made of the chlorate of potassa?

A. It enters into most of the materials used for lucifer matches.

Q. Are there any insoluble salts of soda?

A. One only; the antimoniate; the antimoniate of potassa is therefore the only test for soda by precipitation.

Q. Repeat the fact of most importance in aiding us to determine the existence of sodium in a compound.

A. It is, that compounds containing sodium always give a yellow color to the flame of alcohol.

Q. What is one mode of testing for potassa by precipitation?

A. ~~The~~ addition to the liquid to be tested, of tartaric acid in excess; which will form the almost insoluble bitartrate of potassa, or cream of tartar.

Q. Are there other tests for potassa?

A. Yes. Perchloric acid, and Fluohydrosilicic acid, each will form precipitates in any solution containing potassa. The same is true of Carbazotic acid.

Q. What affords, however, the most delicate test of all?

A. The Bichloride of Platinum, or Chloroplatinic acid.

Q. What is the color of the precipitate in this case?

A. Light yellow.

Q. What is its composition?

A. It is a double salt, — of the chloride of platinum and the chloride of potassium.

Q. Does lithia abound in nature?

A. No; it is found only in some rare minerals, called petalite and spodumine &c.

Q. Is the carbonate of lithia soluble?

A. No; the insolubility of its carbonate distinguishes it from the other alkalies.

## The Alkaline Earths.

Q. What are the four alkaline earths?

A. Baryta, strontia, lime and magnesia.

Q. Which of these is most soluble in water?

A. Baryta.

Q. Which of them is the least soluble?

A. Magnesia: their solubility follows the order in which they are enumerated above.

Q. Are baryta and strontia closely allied?

A. Very; ~~being~~ frequently found together in native min-erals.

Q. Which forms the heaviest salts?

A. Baryta; its name ~~having~~ been derived from this fact.

Q. The salts of which are poisonous?

A. Those of ~~baryta~~.

Q. What is one ready mode of distinguishing the salts of strontia?

A. Adding the suspected material to burning alcohol. Any compound of strontia will ~~give~~ a peculiar blood-red hue to the flame.

Q. What acid forms an insoluble salt with strontia, and a soluble one with baryta?

A. Chromic acid. The chromate of strontia is insoluble.

Q. Which of these alkaline earths forms the most insoluble carbonate?

A. Baryta.

Q. Is the sulphate of strontia soluble?

A. No, — unless in a large proportion of water.

Q. What is the most insoluble of all sulphates?

A. The sulphate of baryta.

Q. What is, therefore, held to be the best test for sulphuric acid?

A. The chloride of barium.

Q. Do baryta and strontia both readily form hydrates with water?

A. Yes.

Q. Have they decidedly alkaline reactions?

A. Yes.

Q. What salt of lime is most abundant in nature?

A. The carbonate.

Q. What are some forms in which carbonate of lime exists?

A. Marble, - chalk, calcareous spar, &c. Its most beautiful specimens are the stalactites and stalagmites found in some caverns.

Q. How are these supposed to be deposited?

A. From solution in subterranean streams, containing an excess of carbonic acid; which dissolves this and several other carbonates.

Q. How may lime be obtained pure from its carbonate?

A. By exposure to red heat, - which volatilizes the carbonic acid.

Q. What is Quicklime?

A. Anhydrous lime.

Q. In what does the process of slaking consist?

A. In the formation of a hydrate by the union of lime with water. A definite compound is formed, of one equivalent of each.

Q. Is this soluble?

A. Yes. It is, however, nearly twice as soluble in cold water as in hot.

Q. Is not this an exception to the general rule?

A. Yes.

Q. May calcium be reduced by heat, with carbon, from lime?

A. It may; and also from the chloride of calcium, by aid of the voltaic battery.

Q. Is lime the protoxide of calcium?

A. Yes.

Q. What is the most important property of the chloride of calcium?

A. Its very strong affinity for water. It is used on this account to assist in concentrating alcohol &c.

Q. How many equivalents of water do the nitrate and sulphate of lime contain?

A. 2 equivalents.

Q. Does the sulphate chrystallize?

A. It does.

Q. Is it soluble?

A. Partially so only: it requires, that is, a large proportion of water to dissolve it.

Q. Is it more soluble in carbonic acid water?

A. Yes; it exists, thus dissolved, in some natural waters.

Q. What is the familiar name of sulphate of lime?
A. Gypsum, or plaster of paris.
Q. How may we readily detect the presence of lime in any solution?
A. By the addition of carbonic acid, which will render it turbid.
Q. What is a still stronger test, however?
A. The oxalate of ammonia; forming the very insoluble, white oxalate of lime, — a transparent precipitate, which will not filtrate through a cold filter, — and which is farther distinguished by its solubility in the acids.
Q. Why will not uncombined oxalic acid answer as well for the above purpose?
A. Because, if sulphuric acid be present, it will decompose free oxalic acid.
Q. What portion of our bodies contain phosphate of lime to a large amount?
A. Bones and teeth. It is a subphosphate in this case, — containing 8 parts of lime to 3 of the acid.
Q. How is "bleaching salt" produced?
A. By passing chlorine into hydrate of lime.
Q. What is its chief ingredient?

A. Hypochlorite of lime.

Q. Does magnesia also abound in the form of carbonate?

A. Yes; as well as in that of its silicate, of which soapstone is an example.

Q. What acid is employed to separate magnesia from these salts?

A. Sulphuric acid.

Q. What is the common name of the sulphate of magnesia?

A. Epsom salts.

Q. Is it soluble?

A. Perfectly so.

Q. What is the order, then of solubility of the sulphates of the alkaline earths?

A. That of magnesia first, of lime next, of strontia third, and that of baryta most insoluble of all; being exactly the reverse of the order of solubility of the alkaline earths themselves.

Q. Is the solubility of its sulphate an important characteristic of magnesia?

A. Yes.

Q. In what form does sulphate of magnesia chrystallise?

A. In needleshaped prisms.

Q. What proportion of water do these contain?

A. 7 equivalents; being thus the type of a class or family of salts, — called "magnesian" from their analogy in this respect.

Q. With what poison may Epsom salts be confounded, from similarity in appearance?

A. With oxalic acid.

Q. How may they be distinguished?

A. Firstly, by the intensely sour taste of oxalic acid. Also, by the fact that magnesia will render a solution of oxalic acid turbid by precipitation; — and that chloride of barium or liquor potassae will have a similar effect with solution of sulphate of magnesia.

Q. Of the seven equivalents of water which Epsom salts contains, how many may be driven off by heat?

A. All but one, — called, hence, its constitutional water.

Q. Is this fact characteristic of the "magnesian family" of salts?

A. Yes. This equivalent of water may, however, be substituted by another salt, — forming a double sulphate.

Q. What constant distinction exists between double salts, of the above named kind, and salts of poly-basic acids, — containing two bases?

Q. Besides the different proportion of acid,—this rule exists; that in salts of polybasic acids, the bases associated together are always of the same class, and analogous in their affinities; as in the tartrate of potassa and soda, for example; which is not the case in true double salts.

Q. What effect have ~~[illegible]~~ alkalies upon solutions of salts of magnesia?

A. They precipitate the magnesia in the form of a hydrate,—by taking the acid combined with it.

Q. What occurs if we add an alkaline carbonate to a solution of a salt of magnesia?

A. The insoluble carbonate of magnesia is precipitated.

Q. How is magnesia procured for medicinal use?

A. By calcining the carbonate.

Q. Is magnesia soluble in water?

A. No; except in a very large proportion of it; it is the most insoluble of the alkaline earths.

Q. Does magnesia absorb carbonic acid from the air, as solutions of the other alkaline earths do?

A. No,—it does not.

Q. By what other test is magnesia distinguished from baryta, strontia, and lime?

A. By the solubility of its sulphate.

Q. What more precise and complete test for ~~mag-~~ it
~~-nesia exists~~ exists?
A. A mixture of phosphate of soda or potassa with ammonia.
Q. What kind of precipitate does magnesia or its compounds form with such a mixture?
A. The white, granular, tribasic phosphate of magnesia and ammonia.

## The Earths.

Q. What are the bodies called earths?
A. Alumina, Glucina, Yttria, Zirconia, Erbia, Terbia and Thoria.
Q. In what forms does Alumina occur abundantly in nature?
A. As an ingredient in alum, in feldspar, and clay. Pure clay is uncombined alumina.
Q. What is alum?
A. The double sulphate of alumina and potassa.
Q. What is feldspar?
A. The double silicate of the same bases.
Q. What are the properties of pure alumina?
A. It is a white solid, having a strong affinity for water, and capable of absorbing colored liquids freely. It is hence used to fix colors in dyeing.

Q. How may alumina be obtained by precipitation?

A. By ~~the~~ addition of ~~an alkali~~ ammonia or its carbonate to a solution of its sulphate.

Q. Is it known what proportion of oxygen exists in alumina?

A. Not with certainty. It is supposed, from its analogies in combination, to be a sesquioxide of aluminium; $Al_2O_3$.

Q. Does aluminium uniformly act the part of a base, in combination?

A. No; it unites with some bases as an acid, forming salts, which may be called aluminates.

Q. What is the appearance of the precipitate of alumina thrown down from a solution of alum by ammonia?

A. It is gelatinous. It is soluble in potassa or soda.

Q. Will carbonic acid form a carbonate with alumina?

A. No; there is no carbonate of alumina.

Q. What gave rise to the name of Glucina?

A. The sweetness of its taste.

Q. In what mineral substances does it exist?

A. In the beryl, emerald, &c. The emerald is a silicate of glucina.

Q. How may it be readily distinguished from alumina?

A. By the fact that it is soluble in carbonate

of ammonia, and is therefore not precipitated by it.

Agitation causes Congelation of water unfrozen at 32°
Agitation causes explosion of Euchlorine gas.
Rational study of Phys. Forces fortifies for war against Homeopathic absurdities –
Table turning & Anim. Magnetism
Study of life & excitomotor phenomena & of mental physiology gives resistance to spirit Rapping nonsense.

Drummond –

*

Caustic potash heated with caustic lime & acetate of soda ?